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Ala. GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, *State Geologist*

IRON MAKING IN ALABAMA

THIRD EDITION

By

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UNIVERSITY, ALABAMA.

1912.

THE
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LETTER OF TRANSMITTAL.

TO HIS EXCELLENCY,
GOVERNOR EMMET O'NEAL,
MONTGOMERY, ALA.

DEAR SIR:—I have the honor to transmit herewith as a report of the Geological Survey, the third edition of Iron Making in Alabama, by Dr. William Battle Phillips. The two previous editions of this report were very quickly exhausted and there has been for some time a rather pressing demand for the third edition, which was prepared by Dr. Phillips and was ready for the printers in 1908. It was, however, impossible to secure from the previous administration the authority for the printing of this report, and it has in consequence gotten somewhat out of date.

When this authority was obtained from yourself, Dr. Phillips was in another state and could not well, without great inconvenience, keep fully informed as to the changes in the organizations and administrations of the various furnace plants, rolling mills, etc. Fortunately Mr. Frank H. Crockard became interested in the matter, and through his active efforts these parts of the report have been brought up to date, and he has in addition contributed a timely and valuable article on Steel Making in Alabama.

We are also indebted to Mr. Haehnlen for an account of the working, at Woodward, of a system of by-product coke ovens recently introduced into this State, and to Mr. David Hancock for an article on Coal Washing in Alabama.

The manuscript with these revisions and additions was submitted to Dr. Phillips and has had the benefit of his final revision.

One can readily see that with such an interval between the preparation of a report of this kind and its final submission to the printers, some discrepancies and even contradictions will almost inevitably be overlooked in the proof reading and will be found in the text.

I wish to express my obligations to Messrs. F. H. Crockard, James Bowron, W. J. Penhallegon, Erskine Ramsay, J. H. Haehnlen, and David Hancock for valuable aid in connection with the present report.

Very respectfully,
EUGENE A. SMITH,
State Geologist.

University of Alabama,
August 1, 1912.

GEOLOGICAL CORPS.

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Herbert H. Smith	Curator of Museum.
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W. G. Early	Pera, Pea River.
J. F. Hicks	Beck, Conecuh River.

From the records of the daily observations of the gage readings at these places when extended through sufficient time, the calculations of available horse power to be obtained from the different streams are made.

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INTRODUCTION.

Since the appearance of the first Edition of this work, in 1896 (a second Edition having been called for in 1898) there have been many and great changes in the iron industry of Alabama. Looking always towards the manufacture of finished products from pig iron these changes and improvements have found their legitimate consummation in the establishment of the steel plant, at Ensley, by the Tennessee Coal, Iron & Railroad Company. If there had been no other improvements this alone would mark an era of the utmost importance to the stability of all the enterprises connected with the production of iron. The early experiments at North Birmingham with the so-called Henderson process and the later success attained by the Birmingham Rolling Mill with basic open hearth steel have borne fruit and the establishment of the large steel plant at Ensley is the direct result of the work done twenty years ago.

The first basic open hearth steel made in Alabama was produced by the Henderson Steel & Manufacturing Company in an experimental furnace erected at North Birmingham. The first heat was poured March 8th., 1888, by E. E. Robinson, melter. The furnace was of 15 tons capacity and made 200 heats before it was closed down. The maximum output during any one day was 25 tons and the total production was about 1600 tons. The steel was sold, as ingots, to the Bessemer Rolling Mill Company, Bessemer, for $22.00 a ton. Excellent boiler plate was made from the ingots and some of it was worked up by Crellin & Nalls, Birmingham, the boilers going into the grain mill of Mr. (afterwards Governor) B. B. Comer.

To this enterprise succeeded the Jefferson Steel Company and operations were resumed at the original furnace, remodelled, in 1892 and 1893, under the supervision of Ernst Prochaska. The operations were again suspended during the summer of 1893 and the furnace has not been in commission since that time. About the year 1892-93 a little basic open hearth steel was made at Fort Payne, but no definite information can now be secured.

The matter of steel making rested until 1897 when the Birmingham Rolling Mill Company built two open hearth steel furnaces, each of 35 tons capacity. The first heat was made July 22, 1897, and the second furnace went in on the 25th of October. This plant did not continue long in operation, as the last heat was poured November 12th, 1898. For a further historical account of this matter reference is made to the Chapter on Steel Making in Alabama, by Mr. Frank H. Crockard, Vice-president and General Manager of the Tennessee Coal, Iron & Railroad Company, which has been prepared especially for this publication. It is particularly fortunate that Mr. Crockard was willing to contribute this chapter, for there is no one who can speak with more authority than he whether from the business side or the technical side. I desire here to express my deep acknowledgments to him, for this attempt to set forth the principal features of the iron and steel industry in Alabama. This Report would have been singularly incomplete without this chapter.

The sources of the material for which the writer is not personally responsible are freely and gratefully acknowledged. To Mr. W. H. Brannon, of the Tennessee Coal, Iron & Railroad Company, for the article on The Grading of Pig Iron; to the reports of the Alabama Geological Survey, prepared both by Dr. Eugene A. Smith, Director, and Mr. Henry McCalley, chief assistant, and to the yearly publications of the United States Geological Survey, Division of Mineral Resources.

The writer's intimate acquaintance with the iron industry in Alabama began in 1888. Since that time he conducted a private metallurgical laboratory in Birmingham and served for four years as chemist and metallurgist for the Tennessee Coal, Iron & Railroad Company, and the Birmingham Rolling Mill Company.

During the last years, however, he has been Director of the Bureau of Economic Geology and Technology of the University of Texas.

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In this connection special mention must be made of the various reports of the Alabama Geological Survey and particularly of the reports on the Valley Regions of Alabama, 1907, by Mr. Henry McCalley, Assistant State Geologist.

WM. B. PHILLIPS.

Austin, Texas,
December, 1911.

IRON MAKING IN ALABAMA

CHAPTER I.

THE ORES—GENERAL DISCUSSION.

The ores used in the production of pig iron in Alabama are of three kinds, the red fossil ores of the Clinton, the brown ores (limonites) and the gray ores (hematites). Since the appearance of the second Edition of this work, in 1898, the hematite ores of the Sylacauga district, have come into use and the outlook for the development of a new source of supply is promising.

No blackband, or carbonate ores, are used in the State. Fifteen years ago an attempt was made to use a blackband ore, found in the northern part of Jefferson county, but the furnace worked badly and nothing came of the experiment. Even after calcining the ore in the open air, the resulting material was not considered satisfactory. For special purposes, as for instance, when a special kind of car-wheel iron is desired or some particular variety of iron for use in pipe works, brown ores alone are used in the furnace. Even in such cases, however, it has become a common practice to mix the brown ore with ordinary red ores. But for all ordinary purposes the practice now is to use a mixture of red fossil ore and brown ore, the proportion of this latter rising to 30 and 40 per cent, according to circumstances.

In Alabama a great deal of prospecting has been carried on for the last thirty years and the character of the available deposits of ore is now fairly well established. During the flush times preceding 1893, several chemical laboratories were in active operation and many analyses were made of all kinds of material. In some cases the samples were taken by interested persons and in other cases by those who were unacquainted with the first principles of sampling seams of ore. In the writer's own experience it has happened more than once that a single piece of ore, not larger than the fist, would be brought

in as representing the entire seam. In one case of this kind the ore showed a comparatively small amount of phosphorus, with about 46 per cent of iron. It was then reported that a large deposit of Bessemer ore had been discovered, but the statement was without foundation in fact. If there is any large deposit of Bessemer ore in the State it has not yet been discovered. There are places along Red Mountain where the ore shows much less phosphorus than it generally contains and there are also places where the content in phosphorus is above 5 per cent. There are places where some of the brown ores show phosphorus below the Bessemer limit, while fifty feet away they are liable to carry from 0.20 to 0.50 per cent.

The same observation applies to certain seams of soft red ore. Many seams have been carefully sampled and many analyses have been made in the search for ore that would not show phosphorus above the Bessemer limit, i. e., not over 0.05 per cent. for 50 per cent of iron. But the conclusion has finally been reached, as was stated in the second edition of this book, that we shall have to use ores that contain from 0.10 to 0.40 per cent. of phosphorus per 50 per cent. of iron, and in many of the brown ores there will be a considerable increase over these figures. It is not denied that with a small furnace and great care in the selection of the ore, it is possible to make Bessemer iron in Alabama, but no one could be advised to undertake it, in so far as concerns present information. The attempt has been made and several thousand tons of iron with less than 0.10 per cent. of phosphorus were produced, but the enterprise languished and has not been revived. The objection to this particular lot of iron was said to have been based on an unusually high content of sulphur.

The treacherous nature of brown ore with respect to the continuity of the deposit, to say nothing of the extreme variations in the phosphorus content, is enough to forbid reasonable hope of success.

The red ores and the magnetites carry phosphorus much above the Bessemer limit, the content being, for the most part, between 0.30 and 0.40 per cent. In the district contiguous to Birmingham there is a small seam of red ore that carries 5.41 per cent. of phosphorus and another with 2.31 per cent, the metallic iron in each case being about 38 per cent.

Inasmuch as the basic Bessemer process, with consequent production of slag for fertilizing purposes, is not used in this

country, these high phosphorus ores could be employed only in the production of ferro-phosphorus. They are not at present mined, and mention is here made of them merely to point out the fact that the red fossil ore, in places, carries an unusually high percentage of phosphorus.

The chemical inspection of ore has made wonderful progress in the State during the last few years and there are but few furnaces which do not employ a chemist. One of the companies, engaged also in steel-making, employs 30 chemists. Although the laboratory is depended on to an extent which a few years ago would have been considered impossible, the greater part of its work is directed towards the inspection of products rather than towards the inspection of the raw materials. It is not meant, by this, that the quality of the raw materials is considered of secondary importance. More and more attention is being given to this matter and when one compares what was not done a few years ago with what is done now he can not fail to note the improvements in the chemical side of iron making.

It is practically impossible to keep as close a watch over the ores in Alabama as is done, for instance, in Pennsylvania, Ohio and Illinois. The conditions are radically different and a different procedure must be adopted. There is no such uniformity in the composition of the ores at the disposal of the Alabama iron-maker as is found in northern and north-central districts, and it is practically impossible to grade ores here as they are graded there.

As compared with the practice in the north and north-central districts the custom in Alabama is not to carry large stocks. There are, however, important exceptions to this rule. In the case of the largest steel producer it is not unusual to carry 500,000 tons and more of ore, 100,000 tons of coke and 40,000 to 50,000 tons of dolomite, all carefully graded according to chemical composition.

A large and an increasing amount of ore is bought on analysis, but the needs of the furnaces are so imperative that a large proportion of any shipment is already made into pig iron before the chemist has had time to sample and analyze. It does not, of course, take much time to make the analysis, but it requires a good deal of time to secure a fair sample of any shipment. If the ore-shipper is under contract to deliver ore of a minimum content in iron he strives to do his best, but this

best would fall far short of the requirements in other districts more fortunately situated with respect to ore supplies. If a car or two is sometimes of so much lower grade than the average that the inspector at the furnace can see for himself, without analysis, that it is not up to the standard, there may be a penalty attached, but the ore goes into the furnace and the claim is adjusted afterwards.

The principles underlying the valuation of iron ores are but little used in the State, the old system of purchasing by the ton still being maintained, for the most part. While there has been a marked improvement in this direction during the last few years and a notable extension of chemical inspection over the ores it may not be said that ores are bought strictly on analysis. The ores are analyzed, but the enforcement of the contract does not depend on their composition. Within certain limits the price is uniform, no matter what the composition of the ore may be. It may be improperly mined, it may contain unusual amounts of slate, or clay, or chert or water, but if the furnace-man can use it at all it is dumped in the stock-house and the seller notified that "such and such a car contained very poor stuff, please be more careful." A carload of ore may contain 47 per cent. of iron today and tomorrow, from the same mine, four or five per cent. less, but the price is the same.

There are two main results from this system: First, the contractor is not impelled to furnish ore any better than will pass inspection. His purpose is to avoid disputes with the furnace-man by sending ore that indeed could be better but still will pass muster. In the mining of soft ore by open cut or short drift, and in the underground mining of hard, or limy, ore it is practically impossible to distinguish between ore of 45 per cent. and ore of 40 per cent. of iron by the eye, or to say that such and such hard ore will carry sufficient lime to be self-fluxing. The chemist alone can decide such questions.

In the Birmingham district the contractors are fully alive to the advantages of shipping ore that will cause no dispute. Under the present system it is difficult to see how they can ship better ore than they do ship.

The daily needs of the furnaces are so great that ample latitude must be allowed to the independent ore shippers and to the superintendents in charge of properties owned by the furnace companies themselves. Just what this should be de-

pends on circumstances. A rule that would apply fairly to soft ore might not apply as well to hard ore or to brown ore. Perhaps a reasonable rule would be that each mine must conform to a certain standard to be determined by the average content of iron from that mine over a certain period. This rule applies in many of the great northern districts and in practice it has been found to work satisfactorily. Aside, however, from the prevention of disputes between ore shippers and ore consumers there is a far weightier matter involved in the lack of sufficient chemical inspection of the ore, the furnaceman can not know that his ore is of the same composition today as it was yesterday or will be tommorrow. The purchase of ore on analysis, while it does not necessarily condition regularity of stock, yet is a long step towards it.

Irregularity of stock is one of the most serious obstacles with which the Alabama iron-master has to contend. This applies to all kinds of ore but especially to Red Mountain ores. The most untiring vigilance is demanded, day and night, in order that the entire make of the furnace shall not be injuriously affected. Uniformly good iron can not be made at a uniformly low price with irregular stock and it is true that variations in the cost of producing iron are due, in a marked degree, to variations in the composition and condition of the raw materials, irrespective of labor costs, &c. About three-fourths of the cost of producing iron in Alabama is chargeable to the cost of the raw materials and an improvement in the quality of these affects the cost sheet more rapidly and more radically than any other item or combination of items. From 26 to 30 per cent. of the cost of making iron is chargeable to the cost of ore, about 42 per cent. to the coke and 3 per cent. to the flux.

It is an old rule, "pay close attention to what is dumped on the bell and the tapping-hole will take care of itself."

There is nothing in the nature of the ores that would forbid their sale on analysis, although the working out of a practical plan might entail both time and money. Whether it would pay to do this is a question which has to be decided according to the special condition affecting it. If it is not always possible to secure the best raw materials they can at least be of uniform composition. While furnace-men may be disposed to make concessions with respect to high grade material they must insist upon having material of fairly uniform composi-

tion. Under the conditions which maintain in Alabama at present and which are likely to exist for many years to come, a greater insistence should be placed on uniformity of composition than on high grade. It is more profitable to make iron from materials which preserve a certain range of composition than from materials which are first class this week, second class next week and no class at all the week after.

Under all circumstances, except such as involve the sale of ore at so much per unit of iron, with a penalty for silica and alumina above a certain point, there will be complaint from the furnace-man that the ore is not as good as it might be, and it will be met by the miner with the assertion that it is as good as it can be for the price.

In 1896 the delivery prices for ore were as follows: Soft ore, 55.4 cents, hard ore 67.5 cents, brown ore $1.00. In 1906 these prices were: Soft ore, first nine months 75 cents, last three months $1.00 to $1.10; hard ore, first nine months $1.00, last three months $1.00 to $1.25; brown ore $1.75 to $1.80. But the increase in price was not attended by a betterment in quality, it was an incident in the general increase of prices without respect to quality. The furnace-man had to make iron with material that cost him a good deal more and with higher priced labor, unsatisfactory at that. If he should today offer more for his ore it is not likely that he could get better material although he could get more of it. A considerable amount of better ore might be secured at a higher price, but it would not affect general conditions.

When the price of pig iron took an upward tendency, in the last months of 1906, the price of ore also rose, but the quality remained about the same.

Attempts at improving the quality of the ores used have been confined. almost entirely, to the brown ores. A brief description of the methods in use will appear later in this book.

The ore that lends itself most readily to beneficiation, without heavy expense, is the limonite, (brown ore, sometimes called brown hematite). Occurring, as it does, in more or less isolated deposits imbedded in clay it was comparatively a simple matter to devise machinery for treating the entire mass, removing the clay by suspension in water and passing the cleaned ore over screens. In this manner the clay, unless very tenacious, was at once separated from the ore, the wash water being collected in settling basins and used over and over again.

The process, somewhat crude at first, has been greatly improved, so that even the tenacious clays, holding pebble ore, may now be handled successfully.

At some establishments it has been the custom to improve the brown ores still further by calcining the washed ore in open piles with wood or charcoal "breeze," and, later, in gas-fired kilns. In this manner the ordinary moisture and the combined water are removed and the content of metallic iron considerably increased. The combined water, i. e. the water which enters as an essential ingredient into the composition of these ores, is not removed under a dull red heat. Calcining the brown ore not only increases the content of metallic iron, it also renders the ore more spongy and, on this account, more easily reduced. Washed brown ore, of 44 per cent. of iron, has yielded as much as 54 and 55 per cent. after being calcined, over a period of several months. While it is customary to wash nearly all of the brown ore used in the State but little calcining is done. The reason for this will appear in the discussion of the brown ores. Unless the deposit is known to be large the erection of calcining kilns could hardly be expected to give much return on the investment. At the same time if such ore was sold on analysis and care taken to maintain a high grade there is no doubt of its being superior to ordinary washed ore.

For improving the soft red ores, and to lesser degree the hard ores, several plans have been proposed, but none has worked its way into actual use. It was proposed to wash the finely ground low grade soft ore so as to remove the more ferruginous portion from the siliceous material and then recover the ore in settling ponds. Some experiments were very successful, but the amount of water required and the practical impossibility of handling large amounts of damp ore in the furnace without its falling to the finest powder have caused an entire suspension of the experiments. Briquetting would probably be too expensive. The soft red ore is a mass of more or less siliceous pebbles held together by a cement of oxide of iron. These pebbles are very small and it was found to be possible to separate them from the cementing material by grinding the ore in a stream of water. During 1894 and 1895 extensive experiments were undertaken by the writer, for the Tennessee Coal, Iron & Railway Company, with a view to utilizing the low grade soft ores. Two separate processes were tried. First, the ore was rendered magnetic by raising it to

a full red heat in a gas-fired furnace and then passing producer gas over and through it. It was found possible to render the ore thoroughly magnetic in this way and to concentrate it over a magnetic separator.

The second process was to dispense with previous magnetization and use the ore direct over a Wetherill separator. This merely required that the ore should be thoroughly dried and crushed to pass a 15-mesh screen, each size passing to a separate machine.

Of these two processes the latter alone is worthy of further consideration and the results attained will be given in the chapter on The Concentration of Ores.

Practically all of the pig iron made in Alabama is obtained from native ore. The only ores brought into the State are a little brown ore from Georgia and Lake ore for "fix" in the rolling mills.

The residue from the roasting of pyrite, in the manufacture of sulphuric acid, known as "purple ore," or "blue billy," is used by the rolling mills as "fix" and also as ore by the furnaces. The mining of pyrite in the State has been begun within the last few years and promises to become an important industry. When the residue from roasted pyrite contains copper, it is extracted by roasting with salt and subsequent lixiviation.

The following tables taken from Advance Chapters of the Mineral Resources of the United States for 1910 will show the rank of Alabama in iron ore production.

States producing in 1910 *more than* 1,000,000 *long tons of Iron ore.*

State	Hematite	Brown Ore	Magnetite	Carbonate	Total Quantity
Minnesota	31,966,769	---------	---------	---------	31,966,769
Michigan	13,303,906	---------	---------	---------	13,303,906
Alabama	3,678,139	1,123,136	---------	---------	4,801,275
New York	64,738	*	*1,222,471	---------	1,287,209
Wisconsin	1,148,846	705	---------	---------	1,149,551

*Brown ore is included in magnetite.

Production of iron ore in the United States, by mining districts and varieties, in 1910, in long tons.

District	Hematite	Brown Ore	Magnetite	Carbonate	Total
Lake Superior	46,328,743	---------	---------	---------	46,328,743
Birmingham	3,300,433	501,682	---------	---------	3,802,115
Chattanooga	712,817	500,742	---------	---------	1,213,559
Adirondack	*	---------	*1,146,080	---------	1,146,080
Northern New Jersey and southeastern New York	---------	†	†598,601	---------	598,601
Other	1,018,636	1,866,148	893,532	22,320	3,800,636
Total	51,360,629	2,868,572	2,638,213	22,320	56,889,734

*Hematite is included in magnetite.
†Brown ore is included in magnetite.

In the Birmingham district are included, besides the mines in the immediate vicinity of Birmingham, those in eastern Alabama that ship ores to the furnaces at Birmingham. In the Chattanooga district are included those mines that ship ores to Chattanooga, Tenn., to Rome, Ga., and to Gadsden and Attalla, Ala. The brown ore mines near Russellville, Ala., and in west-central Tennessee are not included in either district.

Iron-ore mines of the United States that produced more than 1,000,000 long tons each in 1910.

Rank	Names of mines	States	Nearest town	Variety of Ore	Quantity
1	Hull-Rust	Minnesota	Hibbing	Hematite	3,190,093
2	Red Mountain Group	Alabama	Bessemer	Hematite	1,769,067
3	Fayal	Minnesota	Eveleth	Hematite	1,523,836
4	Mahoning	Minnesota	Hibbing	Hematite	1,515,723
5	Morris	Minnesota	Hibbing	Hematite	1,364,680
6	Adams	Minnesota	Eveleth	Hematite	1,288,325
7	Norrie Group	Michigan	Ironwood	Hematite	1,209,335
8	Newport	Michigan	Ironwood	Hematite	1,178,058
9	Shenango	Minnesota	Chisholm	Hematite	1,118,865
10	Canisteo	Minnesota	Coleraine	Hematite	1,105,173
11	Burt	Minnesota	Hibbing	Hematite	1,032,815
12	Leonard	Minnesota	Chisholm	Hematite	1,023,410

The Red Mountain group above includes the mines on Red Mountain, between Birmingham and Bessemer, Ala.

Inasmuch as the available supply of soft red ore is entirely insufficient for the demands made upon it the furnaces will have to depend, for the most part, on hard ore alone or a mixture of hard ore and brown ore. There is still some soft ore to be obtained, but the average quality is not as good as it was a few years ago. It is doubtful whether large shipments with more than 47 per cent of iron could now be contracted for, independently, or supplied by mines of company ownership and operation. The supplies of soft red ore are diminishing at a rate which will soon exhaust them and it will become more and more necessary to substitute brown ore for soft red ore, to use the hard ore alone or with as low a proportion of soft or brown ore as may be possible. Unless new deposits of soft red ore are discovered and opened (and there does not seem to be much hope of this) furnace practice in Alabama will be based on an increasing use of hard ore with as low a proportion of brown ore as will enable the furnaces to run profitably.

It therefore becomes imperative that the closest attention be given to the problems of mining the hard ore and of exploiting deposits of brown ore.

The soft ore will take care of itself. There are not many awkward problems confronting the miner of soft ore, for such mining is practically all open cut work. But the mining and handling of hard ore from depths of 4,000 feet and more, on the dip, calls for the best engineering skill and the best mechanical appliances.

The production of red hematite in Alabama in 1910 was 3,678,139 tons, of which by far the greater part was hard ore, the exact tonnage of the two varieties not being to hand. Probably 90 per cent. of the total tonnage was hard ore. This proportion is not likely to diminish, on the contrary it is likely to increase as the available supplies of soft ore are exhausted. Furthermore, it would certainly be wise to keep small diamond drill holes a long way ahead of the actual work so that the nature of the ore may be proved to great depths along the dip. An inch, or even a 7-8 inch hole would be sufficient for this purpose, the angle of the hole following the inclination of the ore. The cores should be carefully preserved and an analysis

made of each foot in front of the heading. This has already been done in some of the slopes and it should become the general custom. Not only is the quality of the ore determined in this manner, but there is also accumulated, at the same time indispensable information respecting any alterations in the dip of the ore.

In an article on The Development of the American Iron Industry, Engineering Magazine, February, 1906, Mr. E. C. Eckel presented estimates of the minimum values for the workable iron-ore reserves of certain southern States. His figures are as follows:

	Red Ore, Tons.	Brown Ore, Tons.
Alabama	1,000,000,000	75,000,000
Georgia	200,000,000	125,000,000
Tennessee	600,000,000	225,000,000
Virginia	50,000,000	300,000,000
Total	2,300,000,000	725,000,000

Mr. Eckel said: "In considering the above figures it will be well to bear in mind that the red ores will average 33 to 43 per cent. metallic iron, but that they carry so much lime as to be almost or quite self-fluxing. The brown ores, as washed, will range from 40 to 50 per cent. of metallic iron. It may further be added that the estimates as to red-ore tonnage are probably much more accurate than those relative to brown ores."

In his figures for the reserves of red ore Mr. Eckel did not include the soft red ore, for he says that such ore as he considered carried almost or quite enough lime to be self fluxing. The soft red ore is, therefore, expressly excluded for it never carries enough lime to flux the silica, to say nothing of the alumina. Furthermore, he does not include the large deposits of red ore which are classed as semi-hard, containing about half as much lime as would be required to flux the silica. There are four distinct classes of red hematite in Alabama, used for making iron: The soft red which rarely carries more than one per cent. of lime, with metallic iron, in exceptional cases, as high as 52 per cent.; the semi-hard, which carries from 35 to 40 per cent. of iron and about one-half as much lime as is required to flux the silica (and alumina); the typical hard ore in which the iron may be taken at about 35 per cent., with al-

most an equal balancing of the lime and silica plus alumina and, lastly, an ore that carries a considerable excess of lime. This latter ore does not, as yet, come much into use and is seen, in its best estate, north of Collinsville, DeKalb county. Many writers on the Alabama ores have entirely neglected the difference between these varieties of red hematite and yet they are readily observed and well known to those who are engaged in the business.

This matter will be referred to again when the character of the different ores is discussed. It is possible to arrive at fairly close estimates of the amount of red ore held in reserve, but there is great difficulty in estimating the reserves of brown ore. The yield of so many tons of washed ore from so many yards of material in the 'bank' can not be taken to mean that this yield may be expected throughout the 'life of the deposit. The yield of brown ore from any deposit is uncertain and varies from day to day. Tomorrow it may be better or worse and the brown ore miner who has a 'bank' of uniform yield is fortunate. If more care was given to the preparation of the brown ore from the "bank" to the car especially in the saving of ore that now goes into the waste dump, there would be a safer basis for calculating the yield of such ore from any given deposit.

There are some brown ore deposits in the State, notably at Shelby and at Baker Hill, which have been worked for many years, the operators at Shelby dating back more than 60 years and at Baker Hill more that 30 years. A vast amount of material has been removed at these places and yet their value as ore producers does not seem to have been impaired. In the history of brown ore mining in Alabama we have come to a time when greater attention must be paid to treatment of the material in the washer and in the jigs. The present methods are wasteful and expensive. They give neither the maximum yield nor the best ore. A large amount of rich ore is allowed to pass the jigs and its recovery will entail the installation of special concentrating machinery.

CHAPTER II.

THE ORES: SPECIAL DISCUSSION.

The Hematites.

SOFT RED ORE.

The hematite ores are, for convenience, classed under two heads:

First, the "soft" red ores, carrying but little lime and, second, the "hard" red or lime ores. The latter ores may still further be divided into "semi-hard" and "extra hard," according as they contain about half as much lime as is required for fluxing the silica and more lime than is necessary for this purpose.

There would, then, be four classes of hematite ore in this State:

"Soft red."

"Semi-hard."

"Hard."

"Extra hard."

The expression "hard ore" has no special reference to physical qualities, but is given to such ores as carry a considerable percentage of carbonate of lime. They are, in a physical sense, harder than the "soft" ores, but the expression is comparable to the use of the word "hard" as applied to waters carring excess of carbonate of lime. The terms "soft red" and "hard red" are in such universal use in Alabama that it is best to adopt them, with the explanations given above.

They belong to the Clinton formation of the Silurian, known as Red Mountain and are sometimes spoken of as the red fossiliferous, dyestone and pea ores. They are true hematites and are not to be confounded with the brown hematites, which are not hematites at all.

The Clinton formation extends, with some important breaks, from the middle portion of Alabama to the northern part of Maine and into New Brunswick. The old Katahdin furnace, in Piscataquis county, Maine, idle now for years, formerly

used the same kind of ore as the Alabama furnaces now use. The formation is also known in Ohio and in Wisconsin, but only in the southern Appalachian region is it now of much importance in the iron industry.

In Alabama the hematites are of commercial importance, so far as known at present, in the counties of DeKalb, Etowah, St. Clair, Blount, Jefferson and Tuscaloosa, by far the greater activity being in Jefferson county.

When one considers the comparatively limited area in Jefferson county which is now mined it is not too much to say that five per cent. of the total area of the Red Mountain formation in the State yields more thatn ninety per cent. of the red hematite produced. In other words ninety-five per cent. of the total area covered by this formation yields only five per cent. of the ore, so that it may be regarded almost as virgin territory.

The dip of the ore being to the southeast it would naturally pass under the Cahaba Coal Field and re-appear on the southeast margin. The red ore has been found in this situation, but it is not mined, at present. Similarly, the ore should pass under the Warrior Coal Field to the northwest, but as already remarked, no deep borings have been made. West Red Mountain also shows the red ore, north and northwest of Birmingham, especially near Thomas, Jefferson county, but the seams are not now workable.

An analysis of an out crop of red ore near Columbiana, Shelby county, southeast of the Cahaba Coal Field, gave the following results:

	Per Cent.
Silica	23.30
Metallic Iron	47.73
Alumina	4.01
Lime	0.75

There have been no extensive developments in this field.

Red Mountain, including the split which occurs near Irondale, Jefferson county, carries workable ores from the southeastern part of Tuscaloosa county to about the middle of DeKalb county, a distance, along a northeast line of about 150 miles. The most southwesterly place at which the ore is now

mined is Dudley, Tuscaloosa county, 40 miles southwest of Birmingham, while the most northeasterly place is Portersville, DeKalb county, 10 miles southwest of Fort Payne.

Along this course of about 150 miles there are many mines now in operation, the largest being within 15 miles of Birmingham.

As a general rule the dip of the ore increases as one proceeds from northeast to southwest, from about 13 degrees to about 25 degrees, but there are local exceptions which materially affect the dip.

It is also a general rule that the thickness and the quality of the ore decrease along this same line, so that the ore in DeKalb county is not as thick or as good as in Jefferson county. The rule as to decreasing thickness of the ore, along this line, holds good, but there are some notable exceptions in regard to quality, which will be noted in the following pages.

The so-called "soft ore" is the upper portion of the seam from which the carbonate of lime has been removed by atmospheric agencies. It seldom contains more than 1.00 to 1.50 per cent. of lime, whereas, on the dip, there is a notable increase in lime. After the "hard ore" has once set in there is a decrease iron of about one per cent, for each 100 feet on the dip and a corresponding increase in lime. But this rule holds good only for certain distances on the dip and certain localities and is not of universal application. If this rule was applicable in every case and the first level of "hard ore" carried 40 per cent. of iron we should expect to find only 20 per cent. at a depth of 2,000 feet, on the dip. But such is not the case. After reaching about 35 per cent. in iron the "hard ore" maintains a comparatively constant composition to the greatest depth now attained, 4.000 feet, on the dip. It is not now known to what depth the ore of this quality goes and for this reason it is highly advisable to extend drill holes from 1,000 to 2,000 feet ahead of the present workings.

The "soft ore" may extend, from the outcrop, for a distance of 300 feet, on the dip, depending on the thickness and imperviousness of the overlying strata, although the hard ore comes to the surface in more than one locality.

In winning the soft ore, the over-burden is removed and the ore is mined, at day, by benches. Under cover the soft ore is sometimes, and the hard ore always, mined by slopes and by drifts turned off from the slopes.

When the over?burden is stripped off there is found a seam of ore quite soft and seemingly much disintegrated. It is of a deep red or purple color and is known as the "gouge." It may be only a few inches thick but often runs to 24 and even 36 inches and comprises; generally, the best part of the seam. The composition of this "gouge" in its best estate is shown by the following analysis made by A. A. Blair for the 10th Census. In not more than two or three localities and then under special conditions does the best soft ore show a higher percentage of iron than is here given.

Analysis of the Gouge, or Best Soft Red Ore.

	Per Cent.
Silica	13.66
Sulphur	0.11
Phosphorus	0.43
Alumina	6.13
Lime	1.26
Magnesia	0.37
Manganese protoxide	0.30
Iron protoxide	0.32
Iron peroxide	75.05
Carbonic acid	0.08
Carbon in carbonaceous matter	0.03
Water of composition	1.62
	99.36

Metallic iron, 52.87 per cent.
Specific gravity, 4.

This analysis represents the average of the analyses given in Vol. XV, 10th U. S. Census, and is calculated on a dry basis.

It may be compared with an average analysis of stock-house samples taken over a considerable period:

Average Analysis of Soft Red Ore, Stock-house samples.

	Per Cent.
Silica	18.50
Metallic Iron	50.80
Alumina	3.65
Lime	1.20

This analysis is on a dry basis. As received at the stock-house the ore had the following composition:

	Per Cent.
Silica	17.20
Metallic Iron	47.24
Alumina	3.35
Lime	1.12
Water	7.00

This represents a better ore than is now supplied to the furnaces, the percentage of iron having fallen materially during the last few years. The heavy demands that have been made during the last ten or twelve years upon the available supplies of soft ore have made themselves felt and it not likely that at the present time the average percentage of iron in such ore, as received at the stock-houses, is above 47 and may not be above 45.

The Ida and the Irondale seams, mined between Birmingham and Gate City, do not carry as much iron as the Greasy Cove ore, St. Clair county. The ore from these seams carries from 40 to 50 per cent.

The Ida seam lies from five to thirty feet above the Big seam and the Irondale seam lies from two to three feet below the big seam.

There is a remarkable difference in the physical appearance of the ore from these three seams. The Ida ore is fine grained and closely knit, the siliceous pebbles are much smaller than in either of the other seams and the proportion of the ferruginous cement is larger.

The Irondale seam is not so close grained as the Ida, but finer grained than the Big seam. In respect to coarseness of grain it stands between the Ida and the Big seam.

The siliceous pebbles in the Big seam are some times one-eighth of an inch in diameter, the general size, however, ranging from one-sixteenth to one-thirty-second of an inch. In all of the seams the pebbles are rounded, with a tendency, now and then, to lenticular shapes.

When boiled in acid and freed from adhering oxide of iron the pebbles are opaque. They are sometimes flattened and when so shaped are larger than usual, some of the flattened pebbles being one-half to one-inch in greatest diameter but

only about one-eighth of an inch thick. It is occasionally observed that these flattened enclosures carry much more lime than the surrounding ore and that the lime (as carbonate) is well crystallized.

Physically, these three seams of ore are composed of more or less ferruginous pebbles held together by a cement of oxide of iron. By crushing and screening even the lowest grade ore it has been found possible to bring the iron in about 25 per cent. of the material from 32 per cent. to 53 per cent., provided that the ore has been crushed to pass a 15 mesh screen. This will be referred to again in the chapter dealing with the beneficiation of the red fossil ores.

The question is often asked, "What is the thickness of the soft red ore that is mined and sent to the furnaces?" It may be answered only in a general way. The upper ten or twelve feet is regarded as fair shipping ore and the content of iron may run to 47 per cent. Below this depth the content of iron begins to diminish and if sixteen feet are taken the percentage of iron falls to about 42 per cent. This applies, of course, to the big seam. All of the Ida seam (seven feet) when good enough, is taken and all of the Irondale seam, (three to four feet.)

The insoluble matter (silica plus insoluble alumina) in most of the soft red ore now runs about 27 per cent., with metallic iron about 44 per cent. The ordinary ratio between the metallic iron and the insoluble matter varies from 1:1.50 to 1:2. To illustrate: water at 7 per cent.

Metallic Iron.	Insoluble Matter.	
40	35.00	For each per cent. increase in metallic iron the insoluble matter falls 2 per cent.
41	33.00	
42	31.00	
43	29.00	
44	27.00	
45	25.00	
46	23.00	
47	22.00	For each per cent. increase in metallic iron the insoluble matter falls 1.50 per cent.
48	20.50	
49	19.00	
50	17.50	
51	16.00	
52	14.50	
53	13.00	
54	11.50	

It is not claimed that this ratio is absolutely correct in all cases, but a large number of analyses substantiate its reliability for all ordinary purposes. The ratio from 40 through 46 per cent. of iron is 1 to 2. Beginnig with metallic iron 47 and insoluble matter 22, the ratio appears to be nearer 1 to 1.50 that 1 to 2. A soft red ore carrying 40 per cent. of metallic iron may be expected to contain 35 per cent. of insoluble matter; one with 45 per cent. may be expected to contain 25 per cent. and one with 50 per cent. of metallic iron 17.50 per cent. of insoluble matter.

The better grades of soft red ore do not occur at all points on Red Mountain, nor is it possible to mine ten feet, profitably, everywhere along the ridge. The inferior ore sometimes sets in at the grass roots and the rich "gouge" is often absent. Mining operations should not be undertaken without careful prospecting and many analyses, for the difference between a fairly good ore and one that is not passable is not detectable by the eye alone. After having become accustomed to a particular kind of ore one may judge of its quality by its general appearance, but for accurate grading analyses are necessary.

In the early days of iron making in the Birmingham district, between 1870 and 1880, before the real value of the lime ore was recognized, the ore burden was composed almost entirely of soft red ore. It has been said that when the limy ore was first encountered in a slope it was thought that the end of the iron industry was in plain view. But the experience of the last twenty years and especially of the last ten years has shown that the salvation of the district depends on the supply of the limy ore. Of recent years it has become necessary to use larger and larger proportions of limy ore in the burden. Some furnaces have run entirely on this burden while others have used and do still use more than 90 per cent. of limy ore in the ore mixture. The relative reducibility of the two ores is still a matter of dispute, but it is thought that the advantage lies with the limy ore. When the soft ore descends into the zone of reduction it may become white hot without materially changing its shape or size, except as these may be influenced by friction and torsional strains during the descent of the charge. The reducing gases act upon it in the lump and if the lumps are of considerable size the reduction to metallic iron is delayed and, the ore may appear before the tuyates unreduced.

It is more imperative that the soft ore be crushed than that the limy ore be crushed, although it is highly advisable that each be crushed.

In the limy ore the lime is present as carbonate (save the small portion existing as silicate and as phosphate), and when this comes to the temperature at which carbonic acid is evolved the ore begins to fall to pieces. The reducing gases can and do have a greater surface to work on and the result is that for a given weight of coke and a given composition and temperature of the gases, there is a greater reducing action. The soft ore is more easily fusible than the limy ore, but this does not mean that it is more easily reduced. On the contrary, a fused crust on the soft ore is more difficult for the gases to penetrate and as this crust becomes thicker and thicker, the reducing gases penetrate with greater and greater difficulty.

When large experiments were conducted by the writer on the magnetization of the low grade soft red ores it was constantly observed that a hard crust was formed on the surface of the pieces, and that the outside would be entirely converted into the magnetic oxide (showing a marked step towards reduction) while the center was comparatively unchanged. In the case of low grade limy ore it was observed that as soon as the carbonic acid came off freely the ore began to fall to pieces and the reduction was carried to the center.

In comparing the two ores another circumstance must not be lost sight of and this is the intimate commingling of the ore and the lime that is to flux it. It would be impracticable to effect by artificial means such an intimate mixture of ore and lime as Nature has already provided in this material. This circumstance is of the greatest importance in any discussion of the relative value of the two ores, the soft and the hard or limy ore. While this latter ore requires a higher heat for fusion it is not on this account to be considered less easily reducable.

The reducibility of an ore depends far more upon its permeability or porosity than upon its fusing point and the loss of energy in the furnace is, for the most part, chargeable to lack of reducing power, rather than to lack of fusing power. There is such a thing as fusing an ore without reducing it or otherwise materially affecting it, but no ore can be reduced without a profound alteration in its chemical nature.

THE LIMY OR SO-CALLED HARD ORE.

This ore sets in sometimes at the outcrop but for the most part it is found only under cover. It is the continuation of the soft red ore on the dip. For distances varying from nothing to 300 feet on the dip the ore is soft, then the hard ore begins and continues to depths not yet ascertained. The deepest workings on the dip are now about 4000 feet and the ore is maintaining a fairly uniform composition.

The ore in Red Mountain dips under the Cahaba Coal Field and appears on the southeastern rim of this field. It has not been mined there. Shades Valley lies between Red Mountain and the Cahaba Coal Field and borings in this valley have proved the existence of the ore seam at vertical depths of 1100 feet, one mile from the outcrop.

The hard ore shows the same variation in thickness and in composition as does the soft ore and about the same thickness is mined, ten to twelve feet.

The soft ore has lost its lime-content by leaching and atmospheric decomposition. Where these agencies have not been at work on so large or continuous a scale the original lime contents are undisturbed. Under heavy and impervious cover we might, therefore, expect to find a better quality of hard ore of more uniform composition. The experience in the district has shown this to be the fact.

The average composition of the better grade of hard ore is as follows:

Average Composition of Good Hard Red Ore.

	Per Cent.
Water	0.50
Metallic Iron	37.00
Silica	13.44
Lime	16.20
Alumina	3.18
Phosphorus	0.37
Sulphur	0.07
Carbonic Acid	12.24

Adding the silica and alumina together we have 16.62, the lime is 16.20 and the ore is said to be self-fluxing.

This term, self-fluxing, is applied to such varieties of the limy ore as show a lime content equal to the sum of the silica

and alumina. It may be urged that an aluminous soft ore requires silica for fluxing the alumina. This is true, but we have to flux the silicate of alumina with lime and it is merely a question of convenience whether all of the bases of the burden shall be calculated as lime and all of the acids as silica, or whether we shall regard the silica plus the alumina as requiring so much lime. In either case, the type of slag to be made must be considered and for any one type the calculations lead to the same result in so far as concerns the consumption of limestone per ton of iron.

The most momentous question in connection with the stability of the Alabama iron industry is whether the hard ore, on the dip, will gradually change into a more or less ferruginous limestone with not enough iron for practical use. What is the lowest permissible content of iron in the hard ore? At what depth will this limit be reached? We have to put aside, for the present, the question of concentrating the low grades of soft and hard red ore and look at the matter as it stands today. The soft red ore is not exhausted, but the demands made upon the available supplies have made themselves felt and within a few years there will not be much soft ore obtainable.

We have to look at things as they are, irrespective of our wishes. Allowing, for the sake of the argument, that no commercial process of concentrating the low grades of soft ore has yet been evolved (an assumption, however, which is not tenable) we shall have to rely upon the limy ore and the brown ore for making iron and steel in Alabama. It is, therefore, of the greatest importance that questions involving the continuity and quality of the limy ore should receive the most careful attention.

It has already been stated that the limy ore is but the soft ore under cover and on the dip. The best grades of the soft ore carry more than 50 per cent. of iron and the best grades of limy ore now carry about 37 per cent. of iron. As we proceed from the outcrop down the dip we find the content of iron decreasing and the content of lime increasing. What is the rate of this change? Is there a point at which the ore will contain so little iron as to be practically worthless for iron making? For certain distances on the dip the decrease of iron is one per cent. per one hundred feet, but this rule does not hold good for all localities, nor in any one locality does it

seem to apply beyond a certain depth. After the limy ore has set in ,and this depth is not a constant, the decrease in metallic iron for the first one thousand feet, on the dip, is about ten per cent, so that a soft ore carrying forty-seven per cent. of iron will change ,at one thousand feet, into a limy ore carrying 37 per cent. of iron. This change begins to be apparent at different distances from the outcrop, but it is fairly uniform for the first one thousand feet. The decrease of iron, one per cent. per one hundred feet, if it were maintained, would bring the content in iron down to 27 per cent. at a depth of 2000 feet. But at a depth of 2000 feet and even to a depth of 2300 feet the content of iron is about 35 per cent. The rule, therefore, that was established several years ago des not hold good beyond the thousand foot mark. What per centage of iron may be expected at a depth of 4000 feet? Will the present percentage maintain itself?

Unfortunately there is no sufficient reply to this most important question. In the absence of small bore-holes carried in advance of the work there is no positive evidence. It would certainly be much to the advantage of the companies to carry these bore-holes along and this could be done, expeditiously and accurately, by means of an electric drill of three-quarters or seven-eighth inch diameter. The core obtained would not only afford positive evidence of the nature of the ore in front, it would also reveal any marked change in dip. This advance drilling is no new thing, it is commonly used in many important mining districts, both ore and coal, and the information to be secured is invaluable.

Considering the vital issues at stake and the extent of the interests involved it is surprising that this work has not been undertaken long ago. One of the companies has had advance drilling done, one or two holes, but the custom is more honored in the breach than in the observance. Large sums of money have been spent in equipping the mines, but not much has been spent in ascertaining the nature of the ore in front of the headings.*

*According to evidence from the deeper slopes and from borings accumulated by E. F. Burchard in Bulletin No. 400 of the U. S. Geological Survey, there is no falling off in the thickness or quality of the hard ore with depth. In some parts of Shades Valley, borings show that the ore continues in practically its outcrop thickness southeastward for 2.500 to 4.000 feet from the outcrop, and in places further. (Page 123.)—E. A. S.

It has been a question among mining geologists whether the Red Mountain ore may not flatten under Shades Valley, but there is very little known on this subject. If the ore does flatten it could be reached by a shaft at much lesser depths than are now indicated by the prevailing dip. If the normal dip be taken at 16 degrees and there is no flattening of the seam we might expect to find the ore at a depth of 1540 feet one mile from the outcrop. If the dip be taken at 20 degrees this depth would be increased to 1980 feet. If, on the other hand, the dip should decrease to 12 degrees the ore would be found at a depth of 1153 feet. As between a dip of 20 degrees and 12 degrees there is a difference of 824 feet in the depth at which one might expect to find the ore.

As already remarked, there is some ground for the assumption that the dip decreases as the ore goes under Shades Valley, but there is not enough evidence to warrant a positive opinion.*

The point is of no little importance, for if the ore can be found in Shades Valley at a depth of 1000 to 1200 feet it might be more economical to mine it through a shaft than to continue the present system of slopes carried down on the dip. A double compartment shaft, with double-deck cage, flat rope and conical drum would enable one to hoist eight tons per trip from a depth of 1200 feet, at a speed of 2500 feet per minute.

The lower limit of iron in workable hard ores remains to be determined, but it does not appear to be feasible to use an ore with less than 25 per cent. A hard ore with less than this amount of iron would necessitate the use of much larger proportions of brown ore than are now used and the price of brown ore is always higher than that of soft or hard ore. The increase in the cost of ore, however, is more than counterbalanced by the smaller consumption of coke and in the betterment of the quality of the iron.

*Observations by Burchard made since the above was written have shown that there is a broad expanse in Shades Valley in which the dip ranges from 8 to 15 degrees, and there are known to be faults in the valley within half a mile of the foot of Red Mountain, as well as indications of sharp folds and possible faults elsewhere in this valley, by which the depth of the ore bed below the surface may be very materially modified. (Bulletin 400, U. S. G. S., page 119.)—E. A. S.

The lower part of the big seam of hard ore shows relatively the same composition as the lower part of the same seam of soft red ore. To come into profitable use it would have to be concentrated. Extensive experiments have been made in this direction, although not of recent years, and the results appear in the chapter on Concentration of Ores. While it is not likely that at this time there is sufficient promise in the beneficiation of these ores to warrant large investments in equipment, &c., yet there are places on Red Mountain where this work could be undertaken profitably. The principles of concentration apply with less force to the hard ore than to the soft, although a considerable improvement is attainable also with the lower grades of the limy ore.

TABLE I.—*Statement of the Thickness and Superficial Area of the Red Mountain Formation, (Upper Silurian) which carries in this State the Principal Supplies of Red Hematite Ore.—Authority, Henry McCalley, Valley Regions of Alabama, Ala. Geol. Survey,* 1897.

County.	Thickness, Feet.	Area, Sq. Miles.
Bibb	10 to 375	4
Blount	225 to 275	10
Calhoun	0 to 500	12
Cherokee	0 to 200	35
DeKalb	175 to 700	10
Etowah	300 to 700	15
Jackson	200 to 225	15
Jefferson	400 to 650	25
Marshall	225 to 300	10
St. Clair	0 to 700	20
Shelby	*	*
Talladega	†	1
Tuscaloosa	150 to 400	10
Total	0 to 700	167

*Not yet determined.
†A few feet.

The thickness of the Red Mountain formation attains its maximum, 700 feet, in the counties of DeKalb, Etowah and and St.Clair, but these three counties combined have not afforded and are not likely to afford, for some years to come, the largest proportion of the ore mined.

In Jefferson county the thickness of the formation is from 400 to 650 feet and the area is not larger than 25 square miles, yet it is by far the heaviest producer of the Red Mountain (Clinton) ore.

Bibb County.

In Bibb county, the Red Mountain formation is from 10 to 375 feet thick and covers an area of 3 to 4 square miles, occurring both northwest and southeast of the Cahaba Coal Field. No red ore mining is now carried on in this county. Two sections may be given:

Section of Cut on Upper Seam of Red Ore in N. W. 1-4 of S. W. 1-4 Sec. 24, T. 21, R. 6 W.

	Feet.	Inches.
Loam; Tuscaloosa formation	—	—
Ore, clay; a hard limonite-looking ore of red brick-dust color, in several solid ledges or seams, from 1 to 4 inches, separated from each other by clayey seams	—	—
Ore; soft, with interstratified clayey streaks	3	—
Ore; soft, good, about	4	—

An analysis of this ore by J. L. Beeson gave the following results:

Analysis of Ore from Upper Seam:

	Per Cent.
Metallic Iron	60.90
Silica	4.28
Phosphorus	Trace

Section of Cut on Lower Seam:

	Feet.	Inches.
Loam, Tuscaloosa formation	—	—
Ore; soft	2	—
Ore, clay; a hard limonite-looking ore with clayey partings	4	—

An analysis of this ore by J. L. Beeson is as follows:

Analysis of Ore from Lower Seam:

	Per Cent.
Metallic Iron	61.86
Silica	5.16
Phosphorus	0.091

These analyses show an ore high in iron and low in phosphorus, the upper seam havig a mere trace of this ingredient. The locality is well worth further prospecting.

Blount County.

The Red Mountain formation in Blount county has a thickness of 225 to 275 feet and covers an area of about 10 square miles. The ore has been mined at the old Compton Mines on the northwest side of West Red Mountain in the W. ½ of Sec. 27 and the E. ½ of Sec. 28, T. 14, R. 1. E. At this locality the ore was from 2½ to 5 feet thick. The dip near the outcrop was from 30 to 35 degrees northwest, but flattened towards the southeast. Analyses of the soft and hard ores from the Compton mines were made by J. L. Beeson, as follows:

Analyses of Soft and Hard Red Ores from Compton Mines.

	Soft Ore Per Cent.	Hard Ore. Per Cent.
Metallic Iron	56.75	35.52
Silica	10.47	9.50
Lime	—	18.10
Phosphorus	0.32	0.71

West Red Mountain, nearly opposite Chepultepec, is about 300 feet high. The strata carrying the ore have, according to A. M. Gibson, the following section:

Section on West Red Mountain, near Chepultepec, S. W. ¼ of N. E. ¼ Sec. 10, T. 13, R. 1 E.

	Feet.	Inches.
Sandstone; about	10	—
Ore; tolerably good, about	4	—
Shales, sandstones, about	6	—
Ore; not very good	—	10
Sandstones, shales, about	4	—
Ore; fossiliferous, very good, about	1	—
Sandstone; soft, about	20	—
Ore; partly soft and partly hard, with about 4 feet of good ore, it is fine grained and carries streaks of clay, about	7	—
Sandstones; flaggy, about	32	—
Ore; limy, about	3	—
Sandstone; hard and gnarly, without cleavage, yellow, about	15	—
Ore, sandstone, shale, loose, friable, sandy, is probably the "big sandy seam"	50 to 60	—
Pelham (Trenton) limestones.		

Calhoun County.

The Red Mountain formation in this county is from 0 to 500 feet in thickness and covers an area of about 12 square miles. Little or no red ore is now mined in the county. Some work was done several years ago at the old Pryor Mine in the N. W. ¼ of Sec. 19, T. 13, R. 7 E. and the ore was reported to be 12 inches thick. The writer made analyses of the upper and lower seams as follows:

Analyses of Soft Red Ore from Colvin Mountain No. 1 from Pryor mine in N. W. ¼ Sec. 19, T. 13, R. 7 E. and No. 2 from Laney & Piedmont Mine in Sec. 2, T. 13, R. 7. E.

	1. Per Cent.	2. Per Cent.
Metallic Iron	51.66	32.76
Silica	13.85	34.55
Alumina	7.12	9.14
Lime	0.70	0.30
Manganese	Trace	0.20
Sulphur	Trace	Trace
Phosphorus	0.28	0.36

At the Laney & Piedmont mine the ore was 3½ feet thick, but the quality was poor.

The indications of the existence of workable seams of red ore in Calhoun county are not now held to be very promising.

Cherokee County.

In this county the Red Mountain formation has a thickness of 0 to 200 feet and covers an area of about 35 square miles. The ore at Round Mountain has been extensively worked and the following sections give its situation.

Section at Ford New Bank, N. W. ¼ of N. W. ¼, Sec. 33, T. 9, R. 9 E., southwest side of Round Mountain:

	Feet.	Inches.
Shale, cover	—	—
Ore; soft, upper bench	—	6
Shale, *Ore*	1	—
Shale, yellowish	1	6
Ore; reported to be 2 feet in places, lower bench	1	2
Sandstone	—	—

On the southeast side of the mountain and near the furnace the ore has been mined at surface. The dip is 30 degrees southeast. The following section was taken at the mouth of a drift towards the foot of the mountain and near the furnace:

	Feet.	Inches.
Shale, cover	—	—
Ore; soft, good, upper bench	1	6
Shale, *Ore*	—	8
Shale	1	4
Ore (lower bench)	—	5 to 6
Shale (lower bench)	—	1
Ore (lower bench)	—	5 to 6
Mining; a soft black sandy material	—	2
Higher up the mountain the ore is thinner.		

Analyses of the ore from these localities have been made by J. L. Beeson, as follows :(1) Lower Bench at Ford New Bank; (2) Upper Bench at Round Mountain furnace. (3) Lower Bench at Round Mountain furnace.

	(1) Per Cent.	(2) Per Cent.	(3) Per Cent.
Metallic Iron	59.73	53.80	57.26
Silica	5.45	7.57	11.59
Phosphorus	0.20	0.13	0.07

In the Dirtseller Mountains the upper strata carry a seam of compact fossiliferous ore which is said to be 15 inches thick. Near the old Cornwall furnace a good deal of ore has been mined, with a reported thickness of 3 feet, the average thickness, however, being about 18 inches. Analyses of the ore from near the old Cornwall furnace were made by J. L. Beeson, as follows: (1) Upper Bench; (2) Lower Bench.

	(1) Per Cent.	(2) Per Cent.
Metallic Iron	49.61	50.90
Silica	12.14	15.05
Phosphorus	0.57	0.49

The seams of red ore in Cherokee county are thin but some of them are of good quality.

DeKalb County.

Thickness of formation 175 to 700 feet, area covered 10 square miles. S. W. corner S. E. ¼, Sec. 4, T. 10, R. 6 E.

	Feet.	Inches.
Shale	—	—
Ore, shaly	1	6
Shale	2	—
Ore	1	—
Shale	—	—

The strike here seems to be N. 10° E., dip about 60° E. S. E.

A little further to the northeast is the following section:

	Feet.	Inches.
Shale	—	—
Ore, good	—	8
Shale	15	—
Ore	—	10
Shale	—	—

Dip of the ore about 60° S. E.

S. W. ¼ of S. E. ¼, Sec. 4, T. 10, R. 6 E.

	Feet.	Inches.
Shale, visible	5	—
Ore, good and soft	1	3
Shale	8	—
Ore, good and soft	1	3
Shale	—	—

Dip, 80° to 85° E. S. E.

N. W. ¼ of S. W. ¼, Sec. 5, T. 9, R. 7 E.

	Feet.	Inches.
Shale	—	—
Ore and shale	—	9 to 10
Shale	—	3
Ore	1	—
Shale and Ore	—	1 to 2
Ore, shaly on top	3	2
Shale	—	—

Dip about 60° S. E.

N. W. corner of Sec. 33, T. 8, R. 4 E.

	Feet.	Inches.
Ore, about	4	8
Shale, about	18	—
Ore, about	—	4
Shale	10 to	12 feet.
Ore, about	—	3 in.

Dip here about 70° S. E.

Near the center of the N. E. ¼ of S. E. ¼, Sec. 36, T. 7, R. 7 E.

	Feet.	Inches.
Shale, visible	6 to 8	—
Ore	—	2 to 3
Shale	—	1
Ore	—	2
Shale	3	—
Ore	—	0 to 3
Shale	0	8
Ore, good and soft	—	10 to 12
Shale	—	6
Ore	—	5
Shale	3	0
Ore	—	2
Shale, yellowish	—	—

Dip, about 75° N. W.

N. W. corner of Sec. 3, T. 6, R. 9. E.

	Feet.	Inches.
Ore, good solid ledge	—	6 to 16
Shale	—	1
Ore, resembling limonite	—	2

Dip, about 85° N. W.

S. E. ¼ of N. E. ¼, Sec. 29, T. 4., R. 10 E.

	Feet.	Inches.
Shale		
Ore	2	10
Shale, debris	6 to 8	—
Ore	1	6

Another outcrop in this vicinity showed 3 ft. 2 in. of ore.
Dip, about 75° N. W.

N. E. 1/4 of N. E. 1/4, Sec. 34, T. 4, R. 10 E.

	Feet.	Inches.
Ore	1	3
Strata	12 to 15	—
Ore	2	4
Strata, about	210	—
Ore, about	3	—
Strata	50 to 55	—
Ore	1	6
Dip, about 75° S. E.		

About one mile southwest of Fort Payne, at Furnace No. 1, on the northwest side of Little Wills Valley, there is a bored well which is said to have about the following section.

Section of Bored Well at Furnace No. 1, Fort Payne.

	Feet.
Soil	25
Fort Payne Chert (Subcarboniferous)	190
Black Shale (Devonian)	10 to 12
Shales, greenish and gray	340
Limestones, shales, ore; limestones with some shales and from 6 to 8 feet of limy ore in irregular seams	18
Shales, ore; shales with some seams of ore	50
Shales, limestones, sandstones	180
Ore, Big Seam, a coarse ferruginous sandstone	50
Sandstones, shales	40
Pelham (Trenton) limestones and shales (Lower Silurian)	—
	913

In Portersville Gap, near Portersville, the ore has been extensively mined. It occurs in two separate benches with a parting (middleman). The benches of ore are about two feet each in thickness, with about the same for the parting, which, however, is subject to some variation. The writer took samples of the seams near Portersville during the spring of 1908 and made the following analyses:

	(1) 12 inches	(2) 26 inches	(3) 27 inches max. thick.
Metallic iron	29.24	25.30	38.65
Silica	7.60	9.70	15.56
Alumina	4.09	3.55	6.01
Lime	24.54	28.13	11.28

An average analysis of the Portersville ore would correspond to (2) above. Near Collinsville two samples were taken, representing the upper and lower benches. Analyses as follows:

	18 inches top seam	22 inches bottom seam
Metallic iron	36.02	29.14
Silica	9.00	7.84
Alumina	5.01	3.34
Lime	17.86	26.00

The seams of red hematite ore in DeKalb county, as far as explored, are thin, rarely yielding as much as three feet of good ore, and for the most part not exceeding two feet in any one bench. Many other sections could be given, but the matter need not here be protracted further than to give one more, that of an outcrop in Sec. 28 where the ore shows to 30 inches.

W. ½ of N. W. ¼ Sec. 28, T. 9, R. 7 E.

	Feet.	Inches.
Shales, sandstones; the sandstones occur as seams of flagstones in the shales	40 to 50	—
Ore, good and soft, visible	2	6
Shales, sandstones, debris, about	85	—
Ore; a ferruginous siliceous limestone, very fossiliferous	4	—
Ore; a ferruginous friable oolitic calcareous sandstone, a mass of loosely coherent grains of ferruginous sand	10	—
Ore; a ferruginous limestone	8	—
Limestone; siliceous, friable and oolitic, a little ferruginous near the top	3	—
Ore, limy	—	2
Sandstone, of a brownish color	1	—
Limestone; a roughly weathered, very fossiliferous stone of bluish color	3	—
Pelham (Trenton) limestone	—	—

The ore so far mined in DeKalb county appears to belong to the upper ore measures, as the Big Seam (known as the Big Sandy Seam), which runs to 24 feet in thickness, is more than 200 feet below, the thinner and better ore. This sandy seam is hardly anything more than a ferruginous sandstone, carrying so little iron as to be entirely worthless as an ore. It appears to lie immediately above the Pelham limestone and

shows the following section in the N. E. ¼ of S. E. ¼, Sec. 27, T. 7, R. 8 E.:

Ore, limy	3 ft.
Ore; a ferruginous sandstone	8 ft.
Limestone	1 ft.
Ore; ferruginous sandstone	12 ft.
	24 ft.

Etowah County.

The Red Mountain formation in Etowah county varies in thickness from 300 to 700 feet and covers an area of about 15 square miles.

The ore is somewhat thin and is not now mined to much extent.

The following section will illustrate the occurrence of the ore in this county.

Broughton Bridge Gap, N. E. ¼ of N. E. ¼, Sec. 7, T. 11, R. 6 E.

	Feet.	Inches.
Sandstones with some interstratified shales and loam, about	225	—
Shale; *Ore;* in alternate streaks	—	10
Sandstone; very hard, called cap rock to ore	—	2
Shale	—	2
Ore	—	2
Shale	—	2
Ore	1	2
Shales, with interstratified sandstone, about	100	—
Ore; good and soft, outcrop about	3	—
Shales, sandstones, about	175	—
Shales, *Ore;* the ore very sandy and in thin seams in shale	10	—
Loam; sandy, red, with loose shales, about	80	—
Loam, *Ore;* the ore sandy and in loose pieces in red sandy loam, about	10	—
Pelham (Trenton) limestones.		

Considerable surface work has been done near this locality and the ore has also been mined under cover. It is reported that the thickness of the ore, in places, was from 4 to 6 feet, but that it fell to 18 inches within a short distance on the outcrop both northeast and southwest.

At the Low Gap, about a mile north of Attalla, there are two seams of ore, about 30 feet apart. The upper seam has been extensively worked, but the bottom carries only about 8 inches of ore in any one bench.

Following is a section at the mouth of the slope where the upper seam has been mined:

Section at Low Gap, in the N. E. ¼ of S. E. ¼, Sec. 34, T. 11, R. 5 E.

	Feet.	Inches.
Sandstone; soft and yellowish	50	—
Sandstone, shaly, full of fossils	6 to 8	—
Sandstone; in strata of about 2 feet, gray	15	—
Sandstone; soft and yellowish	50	—
Sandstone; gray, very hard	40	—
Shale, debris	20	—
Shale	30	—
Ore, shale; in alternate streaks, the ore is shaly	2 to 2	6
Sandstone, ferruginous and calcareous, very hard breaking like flint and called cap rock. It seems to thicken as the ore thickens	—	8
Shale	2	—
Ore; good	4	—
Shale, about	30	—
Sandstone; hard, bluish and calcareous, called bed rock	40 to 50	—

The dip of the ore here is from 30 to 35 degrees southeast.

About ¾ of a mile southwest of Low Gap the ore is 3 feet thick. About one mile southwest of Low Gap the thickness is from 2 to 4 feet and the seam is vertical for the first 30 feet, then assuming its normal dip to the southeast.

At Low Gap in the immediate vicinity the ore appears to be of about the following composition:

Analysis of Low Gap Ore.

	Per Cent.
Metallic iron	48.00
Silica	9.50
Phosphorus	0.50

At the old Moragne mines ½ mile to a mile northwest of Attalla. the ore was 2 feet and 8 inches thick.

The writer made an analysis of a sample of ore received from Major G. D. Fitzhugh several years ago which was said to represent a seam 3½ feet thick near Attalla. The analysis was as follows:

Analysis of Extra Hard Red Ore from near Attalla.

	Per Cent.
Metallic iron	45.36
Silica	4.55
Alumina	3.82
Lime	14.40
Manganese	0.36
Sulphur	Trace
Phosphorus	0.41

At the Balcombe & Sullivan mines, near Gadsden, the ore is 3½ feet thick and dips to the northwest 80 degrees. An analysis of this ore, made by the writer, is as follows:

Analysis of Soft Red Ore from Balcombe & Sullivan Mines, near Gadsden.

	Per Cent.
Metallic iron	54.91
Silica	9.20
Alumina	4.48
Lime	3.20
Manganese	0.30
Sulphur	Trace
Phosphorus	0.30

The Red Mountain formation in Etowah county is much exposed to local faults and disturbances, although at several places good ore has been profitably mined and there is no reason to hold that the ores can not be advantageously used. The seams are somewhat thin, rarely yielding more than 3½ feet of ore, but some of the ore is of good quality. As the thicker seams elsewhere are mined out and the demand for good ore increases it is likely that some of the ores in this county will be largely used.

Jackson County.

The thickness of the Red Mountain formation in this county varies from 200 to 225 feet and the area covered is 15 square

miles. In this part of the State, extreme northeastern portion, the Red Mountain formation does not seem to carry workable deposits of ore. The rocks are chiefly shales, sandstones and more or less ferruginous limestones. The maximum content of metallic iron does not exceed 20 per cent.

Jefferson County.

This is by far the most important iron-producing county in the State and it is here that the Red Mountain formation attains it greatest commercial development. The thickness is from 400 to 650 feet and it covers an area of 25 square miles. Practically all of the larger mines are in this county and within a few miles of Birmingham.

In Jefferson county there are two distinct ore-bearing belts, known respectively as West Red Mountain and East Red Mountain, the latter being by far the more important of the two.

West Red Mountain extends from the county line on the northeast to Tarrant's Gap on the southwest, with the possible exception of a lapse on Turkey Creek, north of Haygood's X-Roads. From Tarrant's Gap southwest to Valley Creek the formation is faulted, but from Valley Creek southwest it continues to the county line. The distance between West Red Mountain and East Red Mountain varies from 3 to 6 miles, the intervening valley (Jones Valley) being occupied by the city of Birmingham and adjacent towns.

An ideal section of West Red Mountain, opposite Village Springs, 20 miles northeast of Birmingham, is as follows:

Ideal Section of West Red Mountain, opposite Village Springs.

	Feet.	Inches.
Sandstones, shales	—	—
Ore; soft and good	2½ to 3½	—
Limestones, shales	20 to 30	—
Ore; a ferruginous limestone	3 to 4	—
Limestones, shales, sandstones, about	50	—
Ore, sandstones, shales; the ore is a friable coarse grained ferruginous sandstone on the outcrop; it has partings of sandstones and shales with a combined thickness about the same as the ore. It is known as the Big Seam	50 to 75	—
Pelham (Trenton) limestones	—	—
The dip is from 30 to 40 degrees northwest.		

About the best ore that has been exposed in West Red Mountain is found in a test pit that was sunk in the S. E. ¼ of N. W. ¼, Sec. 20, T. 15, R. 1 W., as follows:

Section in Pit in S. E. ¼ of N. W. ¼, Sec. 20, T. 15, R. 1 W.

	Feet.	Inches.
Debris, soil	—	—
Ore; sandy, in large grains	5	—
Shale; yellowish, only in places	—	1
Ore	—	2
Shale, yellowish	—	2 to 3
Ore	1	4
Shale, *Ore;* the shale is yellowish and carries the ore only in places, in streaks	—	6
Ore	1	2
Shale; yellowish	12 to 14	—
Below this point is the Big Seam, as follows:		
Ore; soft, scarlet color	1	—
Ore; shale, in alternate streaks, the ore is sandy	1	—
Ore, shale; the ore is soft and is of black ferruginous coarse sandy grains; the shale is present as thin partings, visible	7	—

The analysis of the ore seams above the Big Seam in this section was made by J. L. Beeson and is as follows:

Analysis of Soft Red Ore, West Red Mountain, S. E. ¼ of N. W. ¼, Sec. 20, T. 15, R. 1 W.

	Per Cent.
Metallic iron	44.32
Silica	31.60
Phosphorus	0.23

Near Thomas, on the electric road to Pratt City, there is an outcrop of soft red ore, fine grained, 4½ feet thick.

It was also sampled and analyzed by the writer.

Analysis of a Seam of Soft Red Ore 4½ feet thick, West Red Mountain, near Thomas.

	Per Cent.
Metallic iron	40.22
Silica	35.20
Phosphorus	Trace

In a cut on the Kansas City, Memphis & Birmingham Ry. (Frisco) at the crossing of the electric road between Pratt City and Ensley there is an outcrop of a fine grained soft red ore 15 feet thick. It was sampled and analyzed by the writer. Analysis of a seam of Soft Red Ore 15 feet thick, West Red Mountain, between Pratt City and Ensley.

	Per Cent.
Metallic iron	24.61
Silica	55.60
Phosphorus	Trace

At a locality on Five Mile Creek, south of Valley Creek, the strata have been bent over until the normal northwest dip becomes a southeast dip. The ore here is about 2 feet thick and has the following composition:

	Per Cent.
Metallic iron	60.71
Silica	9.60
Phosphorus	0.15

In the S. E. ¼ of S. E. ¼ Sec. 34, T. 19, R. 5 W. there is an outcrop giving the following section:

Section of Outcrop, West Red Mountain, S. E. ¼ of S. E. ¼, Sec. 34, T. 19, R. 5 W.

	Feet.	Inches.
Shale; yellow	—	—
Ore; soft and dirty	4	4
Ore; hard, solid and good	1	6
Loam.		

The dip here is 40 degrees northwest. An analysis of this ore is as follows:

Analysis of Soft Red Ore, West Red Mountain, S. E. ¼ of S. E. ¼, Sec. 34, T. 19, R. 5 W.

	Per Cent.
Metallic iron	55.04
Silica	14.85
Phosphorus	0.047

In the N. E. ¼ of N. E. ¼ Sec. 9, T. 20, R. 5 W. there is an outcrop with the following section:

Section of Outcrop, West Red Mountain, N. E. ¼ of N. E. ¼, Sec. 9, T. 20, R. 5 W.

	Feet.	Inches.
Sandstones; flags, visible, about	6	—
Ore; very good, hard	1	8
Ore; very soft, with thin streaks of shale in places	2	4
Ore; about	1	9
Debris.		

The ore here is lenticular. Its normal northwest dip is changed to southeast about 75 degrees. It had the following composition:

Analysis of Soft Red Ore, West Red Mountain. N. E. ¼ of N. E. ¼. Sec. 9, T. 20, R. 5 W.

	Per Cent.
Metallic iron	56.35
Silica	13.85
Phosphorus	0.096

West Red Mountain does not appear to carry workable seams of ore. Where the quality is good the seams are thin and where the seams are thick the quality is poor. With the normal northwest dip the formation goes under the Warrior Coal Field, but does not re-appear on the northwest of this field. Deep borings might reveal its presence but these have not yet been undertaken. Unless there should be a decided flattening of the dip under the Warrior Coal Field the depth at which the ore-bearing formation would be encountered would be too great for profitable exploitation.

Along East Red Mountain during the last thirty years innumerable openings have been made and all of the larger mines are located on this range. The normal dip, southeast, varies from 16 degrees near Irondale to 25 degrees below Bessemer, a distance of some 18 miles. The formation, with a southeast dip, passes under the Cahaba Coal Field and reappears on the southeast of this field, in Shelby county, etc.

On East Red Mountain three distinct seams of ore are recognized, the Ida being the uppermost, the Big Seam in the middle and the Irondale lowermost. The Irondale seam in places is not more than 20 feet above the underlying sandstone.

A section of two miles, opposite Irondale, gave the following:

Section across East Red Mountain, opposite Irondale.

	Feet.
Shales, sandstones; good cover	—
Ore; Ida Seam; compact	5 to 6
Shales, sandstones, *Ore;* the ore in thin streaks	5 to 6
Ore; Red Mountain or *Big Seam,* about	22
Sandstones, shales; yellowish	2 to 36
Ore; Irondale Seam	3 to 5½

In places the distance between the Ida and the Big Seam is from 25 to 30 feet, as the intervening sandstones and shales thicken towards the southwest.

A section at the mines of the old Irondale or McIlwain furnace, southeast of Woodlawn, was as follows:

Section in S. E. corner of Sec. 28, T. 17, R. 2 W.

	Feet.	Inches.
Fossiliferous chert, covering the southeast slope of the mountain	—	—
Shale; Clinton, seemingly about	250	—
Sandstones, yellowish	40 to 50	—
Ore; the *Ida Seam,* very ferruginous fine grained sandstone of a gray color	18 to 20	—
Debris, a few feet.		
Ore; the *Big Seam,* very massive and full of coarse rounded grains or small pebbles of flint	14 to 15	—
Shales, sandstones, yellowish	3	2
Ore; the *Irondale Seam,* good	2	6
Sandstone; yellowish, merely visible	—	—
Debris, very red loam, may cover some ore	40 to 50	—
Debris, sandstones, shales, about	80	—
Sandstone, ferruginous	60 to 80	—
Pelham (Trenton) limestones	—	—

At this place the three seams had the following composition, (1) being the Ida, (2) the Big Seam and (3) the Irondale.

	(1) Per Cent	(2) Per Cent	(3) Per Cent
Metallic iron	36.52	14.23	50.46
Silica	42.92	78.30	21.49
Phosphorus	0.17	0.22	0.021

The Ida Seam, however, in other places carries more metallic iron than this analysis would indicate, but it rarely carries more than 45 per cent. and is never as good as the Irondale Seam. The Big Seam also carries more iron than this analysis would indicate, as will appear further along. In McIlwain Hollow, opposite the town of Woodlawn, there is a notable exposure of ore. The following analyses were made by Ernest Sifford on samples taken by the writer. They represent 29 feet of ore exposed on the west side of McIlwain Hollow, about 1000 feet north of the line of the Birmingham Mineral Ry. (Louisville & Nashville.)

TABLE II.—*Analyses of Soft Red Ore, McIlwain Hollow, Jefferson county, opposite Woodlawn. Descending Order.*

From top.	Silica. Per Cent.	Met. Iron. Per Cent.	Alumina. Per Cent.	Lime. Per Cent.
1st foot	17.00	49.48	5.14	0.45
2nd foot	15.50	51.51	4.68	0.50
3rd foot	15.20	50.80	5.27	0.75
4th foot	15.00	50.70	5.02	0.90
5th foot	13.80	51.10	5.60	1.16
6th foot	16.90	49.68	4.68	0.85
7th foot	17.70	49.08	5.06	1.01
8th foot	18.30	49.28	4.51	0.65
9th foot	23.36	45.03	5.39	0.75
10th foot	41.04	35.93	3.55	0.50
11th foot	45.60	32.99	3.51	0.50
12th foot	27.30	44.33	4.14	0.86
13th foot	30.20	42.80	3.76	1.21
14th foot	33.10	41.19	3.71	0.91
15th foot	34.50	40.68	3.69	1.21
16th foot	34.88	40.58	3.51	1.01
17th foot	37.34	38.46	3.76	0.76
18th foot	39.00	36.41	4.27	1.01
19th foot	39.60	35.72	4.16	1.11
20th foot	39.80	36.93	3.72	0.65

EXPOSURE OF CLINTON ORE, McILWAIN HOLLOW ON RED MOUNTAIN, OPPOSITE WOODLAWN, JEFFERSON COUNTY.

A. SOFT RED ORE MINING, HELEN-BESS MINE, ON RED MOUNTAIN, JEFFERSON COUNTY.

B. THE BIG SEAM OF CLINTON ORE, LONE PINE GAP, ON RED MOUNTAIN, AT BRIDGE OVER BIRMINGHAM MINERAL RAILROAD. JEFFERSON COUNTY.

TABLE II—(*Continued.*)

From top.	Silica. Per Cent.	Met. Iron. Per Cent.	Alumina. Per Cent.	Lime. Per Cent.
21st foot	42.90	33.18	4.39	0.70
22nd foot	41.40	34.50	4.39	0.55
23rd foot	42.20	33.69	3.90	0.60
24th foot	42.90	34.40	3.95	0.25
25th foot	45.50	32.98	3.55	0.50
26th foot	41.30	34.71	4.18	0.65
27th foot	41.60	34.20	4.60	0.75
28th foot	44.70	32.18	4.05	0.75
29th foot	44.80	32.18	4.10	0.75
Upper 10 ft.	10.38	48.25	4.89	0.71
Upper 15 ft.	24.30	45.62	4.47	0.72
Upper 9 ft., separate sample	16.10	49.08	5.60	0.85

The following analyses were made by the writer, of samples taken from the Big Seam between Clifton Junction and Lakeview.

	Upper 5 ft. Per Ct.	Middle 5 ft. Per Ct.	Lower 5 ft. Per Ct.
Metallic iron	42.16	32.51	28.95
Silica	34.30	34.00	52.80
Lime	—	5.15	—

The following analyses were also made by the writer, on samples taken by himself of the Big Seam at the outcrop in Lone Pine Gap (bridge over the Birmingham Mineral Ry.)

	(1) Per Ct.	(2) Per Ct.	(3) Per Ct.	(4) Per Ct.	(5) Per Ct.
Metallic iron	41.30	45.00	44.70	44.00	46.50
Insoluble matter	36.50	34.60	31.80	33.80	29.80

(1) Nine inch "gouge." (2) First and second foot under gouge. (3) Third and fourth foot under gouge. (4) Fifth and sixth foot under gouge. (5) Seventh and eighth foot under

gouge. The average of the last four analyses, representing eight feet of ore, is as follows:

	Per Cent.
Metallic iron	45.05
Insoluble matter	32.50

Opposite Behren's Park other samples were taken and analysed by the writer, with the following results:

	(1) Per Ct.	(2) Per Ct.	(3) Per Ct.	(4) Per Ct.	(5) Per Ct.	(6) Per Ct.
Metallic iron	46.50	40.00	33.50	33.80	37.50	37.50
Insoluble matter	29.00	29.00	30.00	30.46	36.50	40.70
Lime	0.33	7.20	5.25	5.24	0.50	0.50

(1) Upper three feet. (2) Fourth and fifth foot. (3) Sixth and seventh foot. (4) Eighth and ninth foot, (5) Tenth and eleventh foot. (6) Twelfth and thirteenth foot. The average of these analyses, representing thirteen feet of ore, is as follows:

	Per Cent.
Metallic iron	38.10
Insoluble matter	32.60
Lime	3.17

The ore from the Valley View Mines, near this locality, is of better quality than these analyses would indicate, the metallic iron being about 43 per cent.

A section was taken at Green Springs, southwest of the locality just mentioned, as follows:

	Feet.	Inches.
Deep red loam	—	—
Sandstone, shale; ferruginous sandstone with yellow shale parting	15 to 20	—
Ore; very siliceous with flattened grains, black and often soft and friable, about	4	—
Ore; stripped for nearly ½ mile (Big Seam)	25 to 30	—
Shale; greenish	—	4
Sandstone; ferruginous, may carry streaks of ore	3 to 4	—
Shale; yellowish, visible, about	5	—

The Big seam at this place was sampled and analysed by the writer with the following results:

	(1) Per Ct.	(2) Per Ct.	(3) Per Ct.	(4) Per Ct.
Metallic iron	46.15	45.40	46.10	45.90
Insoluble matter	29.40	30.20	29.25	29.70

(1) First 6 feet from top. (2) First 8 feet from top. (3) First 10 feet from top. (4) First 12 feet from top.

Where the Birmingham Mineral Ry. passes through Walker Gap in the N. W. ¼ Sec. 14, T. 18, R. 3 W. there is a fine exposure of the Red Mountain formation with a few inches of Devonian black shale. A section is about as follows:

Section at Walker Gap, Birmingham Mineral Ry., N. W. ¼ of Sec. 14, T. 18, R. 3 W.

	Feet.	Inches.
Fossiliferous chert, visible	65 to 70	—
Black shale, Devonian	—	6 to 8
Sandstone; massive, straw colored	10 to 12	—
Shales, sandstones; the shales of a straw color, the sandstones in thin flags	40	—
Shales; chocolate and pink	10	—
Shales; straw colored	15	—
Ore; shales, debris	10 to 15	—
Ore; sandy	16 to 18	—
Ore, shale, alternate thin strata	18	—
Ore; Big Seam	30	—
Sandstones; impure argillaceous and calcareous flags from 4 to 6 inches each in thickness, with some shaly partings of same rock of a grayish blue color tinged with green	25	—
Ore; a soft black sandy ore with shaly partings	3	—
Sandstone, shale, of a straw or yellow ocher color	15	—
Shale	4 to 5	—
Sandstone; yellow ochreous color	5 to 6	—
Shale; yellowish, visible	15	—

In this section the last mentioned shale dips about 10 degrees southeast, while the Big seam of ore dips about 20 degrees southeast. The Red Mountain formation between Birmingham and Bessemer is, perhaps, more highly developed than at any other points in the State. It is subject to many local

variations, some of them important to the miner. An approximate general section on East Red Mountain, southwest of Walker Gap, may be given as follows:

Approximate General Section of East Red Mountain between Birmingham and Bessemer.

	Feet.
Fort Payne Chert (Sub-carboniferous)	—
Black shale, Devonian	0 to 1
Iron sandstone; very hard, calcareous below surface	6 to 8
Sandy limestones, sandstones, shales	15 to 20
Ferruginous sandy limestone; very limy sandy ore beyond point of weathering	30 to 35
Sandstone	20 to 30
Ferruginous sandstone; very sandy ore	40 to 45
Sandstone	20 to 25
Ore; sandy	2 to 5
Sandstone; sandy ore, a sandstone with 2 to 20 ft. of its central part a sandy ore	40 to 60
Ore; shales; principally siliceous ore with interstratified shale, with the *Hickory-nut* or *gray ore seam*, from 2 to 5 ft. thick, near its top and the *Ida Seam*, 2 to 3 ft. thick, near its bottom	15 to 35
Sandstones, shales	0 to 25
Ore, Upper Bench of *Big Seam*	10 to 22
Parting	0 to 5
Ore, Lower Bench of *Big Seam*	3 to 14
Shales, sandstones	0to 36
Ore, Irondale Seam	8 to 6
Sandstones, shales	25 to 40
Ore, sandy	3 to 10
Sandstones, shales	75 to 125
Pelham (Trenton) limestones (Lower Silurian)	—

The ores from the old Eureka mine, opposite Oxmoor, comprised probably the first red hematite that was extensively used in the manufacture of iron in the State and the first coke iron was made in 1872.

As the matter is of some historical interest two sections will be given, the first at the old Eureka mine No. 1 and the second of the Big seam, opposite Oxmoor, the latter having been sampled by L. H. Goodrich and the analyses made by Otto Wuth.

Section at old Eureka Mine No. 1, S. W. ¼ of N. E. ¼, Sec. 21, T. 18, R. 3 W.

Outcrop of Ore on Red Mountain, Near No. 13 Slope, Ishkooda, Jefferson County.
Tennessee Coal, Iron and Railroad Company.

	Feet.	Inches.
Ida Seam; poor ore about	2	—
Ferruginous sandstone	16	—
Ore, Big Seam; solid, upper 10 feet better than lower 12 feet, about	22	—
Ore; shale in thin streaks, about	5	—
Shale, of golden color, about	0	8
Ore, Irondale Seam; reported to be good and to have a thickness of	4	—

Section of Big seam, opposite Oxmoor.

		Feet.	Inches.
(13)	*Ore*	7	3
	Shales, pebbles	Trace	—
(11)	*Ore*	8	—
	Shales	—	3
(9)	*Ore*	2	3½
	Shale	—	¾
(7)	*Ore*	8	2
	Shale	—	1¼
(5)	*Ore*	1	2½
	Shale	—	2
(3)	*Ore*	—	11
	Shales	7	—
(1)	*Ore*	1	3

The analyses of the ore seams in this section are as follows:

	(1) Per Ct.	(3) Per Ct.	(5) Per Ct.	(7) Per Ct.	(9) Per Ct.	(11) Per Ct.	(13) Per Ct.
Metallic iron	46.79	42.22	41.91	42.36	41.98	43.71	54.98
Silica	16.73	31.91	31.16	31.83	32.04	31.62	16.31
Alumina	2.01	4.05	4.64	4.46	5.13	4.16	3.76
Lime	----	----	----	----	----	1.03	0.68
Magnesia	----	----	----	----	----	0.34	0.21
Sulphur	----	----	----	----	----	----	Trace
Phosphorus	0.16	0.19	0.18	0.19	0.19	0.18	0.21

It will be seen from these analyses, made more than 30 years ago, that there has not been much change in the quality of the ore. The average of these analyses, proportioned according to the thickness of the several strata, gives metallic iron a trifle over 40 per cent. for the 29 feet 1 inch of ore in the section.

At East No. 2 the Irondale seam is 4 feet below the Big seam and is 2½ feet thick. Its composition at this place is as follows:

Analysis of Irondale Seam at East No. 2 Mine, Red Mountain.

	Per Cent.
Metallic iron	40.67
Silica	14.90
Lime	7.48
Phosphorus	0.34

Within two miles and southwest of this place another section was taken by the writer as follows:

Vertical Section at Fossil Mines, Red Mountain.

	Feet.	Inches.
Soil and red clay	4	—
Sandstone	26	—
Clay	—	2
Sandstone	1	4
Clay	—	2
Sandstone	1	2
Clay	—	1
Sandstone	1	7
Clay	—	1
Sandstone	2	2
Clay	—	6
Sandstone	1	1
Clay	—	1
Sandstone	—	8
Clay	—	7
Sandstone	1	4
Clay	—	8
Sandstone	2	—
Ore	2	—
Ore, sandy	3	—
Clay	—	3
Ore, sandy	1	6
Clay	—	2
Ore, sandy	1	—
Clay	1	—
Ore, sandy	—	3
Clay	—	3
Ore, sandy	1	—
Clay	—	3
Ore	—	9
Clay	—	2
Ore, sandy	—	1
Clay	—	6

THE RED ORE MINING PLANT AT NO. 8 FOSSIL MINE ON RED MOUNTAIN, JEFFERSON COUNTY.
TENNESSEE COAL IRON AND RAILROAD COMPANY.

	Feet.	Inches.
Ore, sandy	—	2
Clay	—	3
Ore	1	—
Clay	—	2
Ore	—	9
Clay	—	1
Ore	—	2
Clay	—	5
Ore	—	5
Clay	—	8
Ore	—	8
Clay	—	6
Ore, sandy	—	2
Clay	—	1
Ore, sandy	—	1
Clay	—	1
Ore, sandy	—	4
Clay	—	2
Ore, good	2	—
Clay	—	5
Ore	—	6
Clay	—	2
Ore, good	3	—
Clay	—	1
Ore, good	6	4
Clay	1	5
Ore, good	9	—
Ore and clay, mixed	6	—
	91	—

At this place the over-burden was 66 feet thick and was composed of 56 separate strata. The dip of the ore was 22½ degrees southeast.

According to Smyth (Amer. J'l of Sci., June, 1892) the section of ore-bearing material at Oxmoor, Jefferson county, is as follows; from above:

	Feet.	Inches.
Red sandstone	5	—
Yellow sandstone	6	—
Red sandstone	15	—
Ore (upper 2 ft. soft)	22	—
Shale	6	—
Ore, rich	2	6

A section taken by the writer at East No. 2 mine, Red Mountain, was as follows; from above:

	Feet.	Inches.
Soil and red clay	6	—
Sandstone	3	—
Clay	—	1
Sandstone	1	—
Clay	—	2
Ore	—	6
Clay	—	2
Ore	—	3½
Clay	—	1
Ore	—	4
Clay	—	4
Ore	—	4
Clay	—	0½
Ore	1	1
Clay	—	2
Ore	—	10
Clay	—	1
Ore	—	2½
Clay	—	0½
Ore	—	0½
Clay	—	1
Ore	—	2
Clay	—	0½
Ore, fine grained	—	2
Clay	—	2
Ore, fine grained	1	4
Slate	—	0½
Ore, fine grained	—	5
Clay	—	1
Ore, fine grained	—	7
Slate	—	1
Ore, fine grained	—	4
Slate	—	2
Ore, sandy	—	1
Slate	—	1
Ore, sandy	—	2
Slate	1	—
Ore, sandy	—	6
Slate	—	1
Ore, sandy	—	7
Slate	—	1
Ore, limy	—	2
Slate	—	0½
Ore, limy	—	2
Slate	—	0½
Ore, limy	—	8
Clay	—	0½
Ore, sandy	—	6
Slate	—	3
Ore, sandy	—	3
Slate and sandy ore	—	6
Ore, sandy	—	1
Clay	—	0½
Ore, sandy	—	3

Revolving Tipple, Side View, Woodward No. 3 Red Ore Mine, on Red Mountain, Jefferson County, Woodward Iron Company.

	Feet.	Inches.
Slate	—	1
Sandstone	—	6
Ore, good	10	—
Ore, poor	12	—
	46	7

The 12 feet of lean ore rested on a yellow slate, or shale.

At this place the over-burden was 24½ feet thick and the normal dip of the ore was 19 degrees to the southeast. The thickest single stratum above the ore was 3 feet of sandstone and the over-burden was composed of 56 separate strata.

The thickest single stratum was 26 feet of sandstone as against 3 feet at East No. 2. With the exception of the streaks of limy ore, which were observed at East No. 2 but not at Fossil, the over-burden consists of practically the same materials but the succession and development are different. In the section taken at Fossil there was no limy ore nor fine grained ore such as was encountered at East No. 2. At Fossil the development of sandstone is much more marked and the thickness of the separate benches is greater. It is thought that the section at Fossil is substantially correct. It was taken under some difficulties, the writer having been lowered by means of a block and tackle down the vertical face of the cutting. This is probably the deepest stripping ever undertaken on Red Mountain.

At West No. 2, about 1200 feet southwest of East No. 2, the Hickory Nut seam is 28 feet above the Big seam, while at the Smythe Mines the Hickory Nut seam is 30 feet above the Big seam and has a thickness of 4 to 5 feet. Above the Hickory Nut seam, at this place, and between it and the subcarboniferous chert are about 100 feet of sandstones, shales, &c.

In Tan-yard Gap (Woodward Mines) in the S. E. ¼ of S. E. ¼ Sec. 2, T. 19, R. 4 W., the Ida seam outcrops with a thickness of about 3 feet and is 48 feet above the big seam, while at the Sloss Lower Mines, in S. E. ¼ of N. W. ¼, Sec. 11, T. 19. R. 4 W. the Ida seam is 6 feet thick and is only 10 feet above the Big seam. At this latter locality the Ida seam had the following composition.

Analysis of Ida Seam at Sloss Lower Mines.

	Per Cent.
Metallic iron	41.79
Silica	38.41
Lime	4.07
Phosphorus	0.30

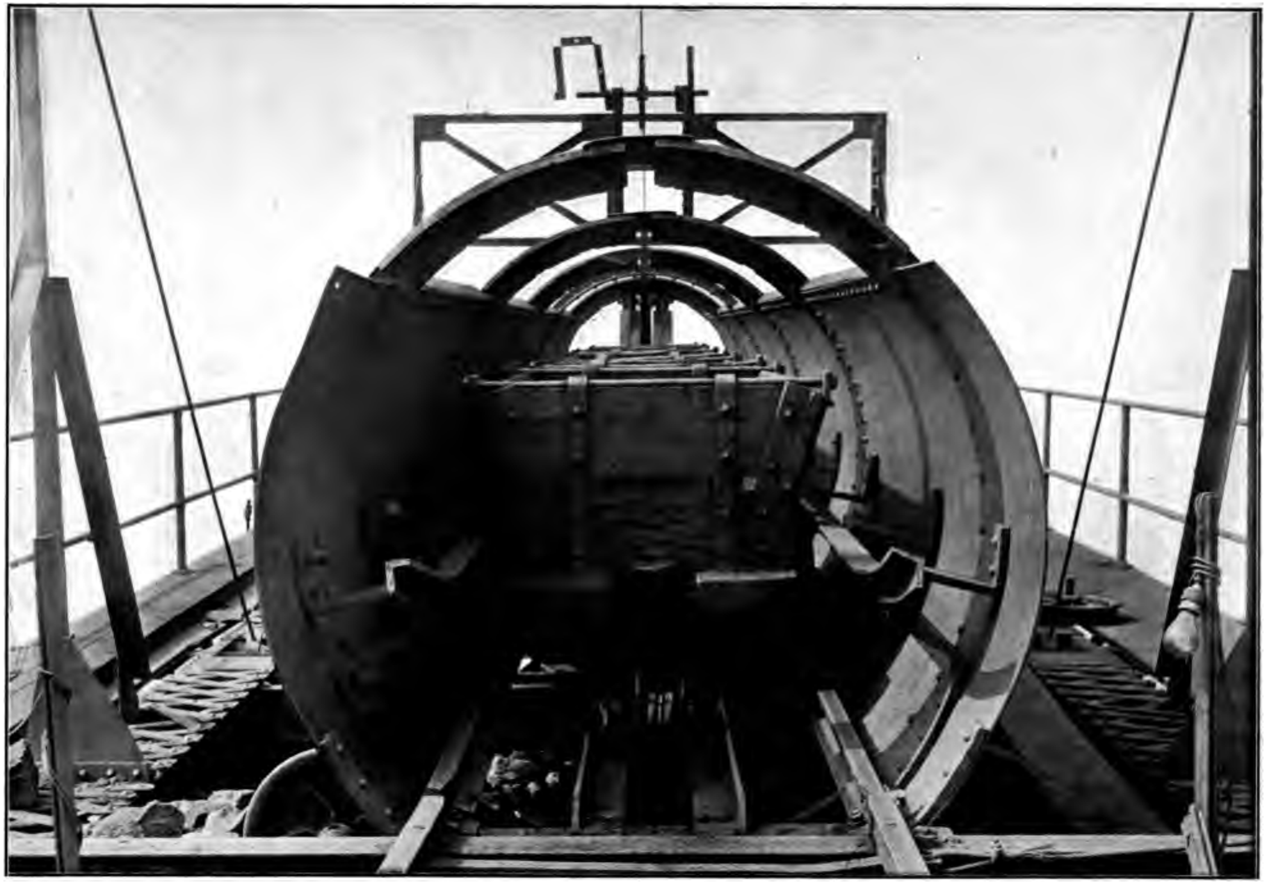
About 1200 feet southeast of Slope No. 1, Sloss, a hole was bored with the following section:

	Feet.	Inches
Fort Payne chert (Lower Sub-carboniferous)	—	—
Sandstone; red, coarse grit	6	—
Sandstone, soft, gray, coarse grit	6	—
Limestone; hard, gray, cherty	7	—
Limestone; ferruginous	33	—
Sandstone; ferruginous	3	—
Sandstone; extremely hard, gray	25	—
Sandstone; ferruginous	43	3
Sandstone; very hard, reddish, fine grit	21	6
Ore; limy	2	8
Sandstone; gray	8	6
Limestone, resembling marble	1	6
Sandstone; hard, gray	2	—
Limestone; ferruginous	6	—
Sandstone; ferruginous	22	4
Ore	15	—
Sandstone; gray	2	6
Slate; ferruginous	—	9
Ore; limy	2	6
Sandstone; highly ferruginous	4	9
Sandstone; highly ferruginous, fossiliferous, mottled	1	8
Calcareous rock, slate; a gray calcareous rock interstratified with sandstone and slate	31	9
	246	8

It is probable that the bottom of this hole is within 30 to 40 feet of the bottom of the Red Mountain formation at this locality.

Analyses of the 15 feet of ore in the above section were made by David Hancock as follows:

Analysis of Core representing 15 feet of ore, 202 feet below surface 1,200 feet southeast of Slope No. 1, Sloss, Red Mountain:



REVOLVING TIPPLE, END VIEW, WOODWARD NO. 3 RED ORE MINE ON RED MOUNTAIN, JEFFERSON COUNTY.
WOODWARD IRON COMPANY.

	Top 4 ft. Per Ct.	Middle 4 ft. Per Ct.	Bottom 4 ft. Per Ct.	Whole Seam. Per Ct.
Metallic iron	37.14	37.29	35.96	36.89
Silica	9.32	11.26	13.82	11.18
Alumina	2.22	2.92	3.44	2.94
Lime	20.23	18.06	19.55	19.55
Phosphorus	0.35	0.33	0.28	0.33

It is interesting to compare the analysis of the whole seam, as taken in the core, with that of the hard ore in the mines at a depth of 350 feet on the slope.

Analysis of a Hard Ore, 350 feet on the slope, Sloss, Red Mountain.

	Per Cent.
Metallic iron	25.94
Silica	16.70
Lime	21.36
Phosphorus	0.32

Car load lots of this ore, from depths varying from 350 to 400 feet, on the slope, gave the following average analysis.

	Per Cent.
Metallic iron	39.31
Silica	11.01
Lime	15.32
Phosphorus	0.34

Many other sections and analyses, bearing on the Red Mountain formation in Jefferson county, might be given, but it is thought that these are sufficient for the present purpose. For more detailed information the reader may be referred to the reports of Henry McCalley on the Valley Regions of Alabama, Ala. Geol. Survey, 1897. These reports have been freely drawn upon by the writer and nearly all the sections given are those taken by Mr. McCalley.*

*The reader is also referred to Bulletin 400 of the U. S. Geological Survey, for later account of the Red Ores of the Birmingham District by Ernest F. Burchard. (E. A. S.)

The area covered by the Red Mountain formation in Jefferson county does not exceed 25 square miles, inclusive of both West Red Mountain and East Red Mountain, and yet it is the seat of practically all of the red ore mining in the State and is likely to continue to be such for many years to come. The formation attains its greatest commercial importance in Jefferson county and within a few miles of Birmingham. The ore seams are thicker in this county than anywhere else in the State or along the course of the formation from New Brunswick southward, a distance exceeding 1500 miles.

While it is indeed true that certain portions of the thickest seams cannot now be utilized, owing to the preponderance of silica, yet the portions that are workable afford a supply of ore that is sufficient for the furnaces now in operation for many years. Whether or no the supply is sufficient for 100 furnaces through 1000 years as has been stated by some spellbinders, may safely be left to those whose acquaintance with the necessities that may arise during this somewhat protracted period is more extensive and more intimate than the writer's.

The day will come when the concentration of the low grade soft ores will be taken in hand. It may not be so far distant as some observers are disposed to think. Under favoring local conditions it could be carried on now with profit, but this assertion meets with the same degree of incredulity as the assertion made several years ago that the sale of Alabama pig iron would be on the basis of analysis within five years. This also has happened and the concentration of the low grade soft red ores will force itself into the trade before many years.

Marshall County.

In this county the Red Mountain formation is from 225 to 300 feet thick and covers about 10 square miles of area. No workable seams of ore have been found in this county. The formation consists of shales, with ferruginous sandstones and limestones. For details of the geologic structure the reader is referred to the reports of Henry McCalley, Valley Regions of Alabama, Ala. Geol. Survey, 1897.

STEEL TIPPLE AT RAIMUND MINE, SLOPE NO. 1 ON RED MOUNTAIN, JEFFERSON COUNTY. REPUBLIC IRON AND STEEL COMPANY.

St. Clair County.

The Red Mountain formation in this county has a thickness of from 0 to 700 feet and covers an area of about 20 square miles, occurring both northwest and southeast of the Coosa Coal Field.

In the N. W. ¼ of N. E. ¼, Sec. 27, T. 14. R. 2 E., there is a seam of ore about 3 feet in thickness which has the following composition: J. L. Beeson, analyst.

	Per Cent.
Metallic iron	50.02
Silica	19.75
Phosphorus	0.17

In the S. E. ¼ Sec. 34, T. 12, R. 4 E. there are two seams of ore with a parting of 6 inches of shale. The analyses are as follows:

J. L. Beeson, analyst.

	Upper Seam 1 1/3 feet.	Lower Seam 2½ ft.
Metallic iron	45.17	57.77
Silica	26.22	9.62
Phosphorus	0.23	0.12

In the N. W. part of N. W. ¼ of S. W. ¼, Sec. 26, T. 15, R. 2 E. near Mrs. Nancy Lovell's, the ore is from 4 to 5 feet thick, with the following composition: J. L. Beeson, analyst.

	Per Cent.
Metallic iron	49.29
Silica	20.00
Phosphorus	0.065

At this place the seam is bent over towards the northeast until its dip is about 40 degrees southeast.

The most favorable locations for workable ore seams in this county appear to be in what is known as Greasy Cove, in the extreme northern part of the county. This cove lies between Blount Mountain and Chandler Mountain and is from 15 to 20

miles southwest of Attalla. It is about equidistant from the Birmingham Mineral Ry. on the northwest and the Alabama Great Southern Ry. on the southeast, four to five miles. Considerable development work has been done in Sec. 25, T. 12, R. 3 E., as also along the ridge south of Tumlin Gap, through which the Birmingham Mineral Ry. runs.

Little or no development work has been done on the hard ore, the openings having been confined to the soft ore.

The soft ore is of high grade, as the following analyses will show. Average analysis of Soft Ore, 7 feet in thickness, along a drift 100 feet in length. Greasy Cove. Sampled by the writer and analysed by Ernest Sifford.

	Per Cent.
Metallic iron	53.65
Silica	7.72
Alumina	5.66
Lime	1.47

An analysis of a pile of about 300 tons of this ore, sampled by the writer and analysed by Ernest Sifford, is as follows:

	Per Cent.
Metallic iron	55.33
Silica	6.14
Alumina	5.02
Lime	1.26

On the road from Tumlin Gap to Gallant Postoffice and within a mile of the line of the Birmingham Mineral Ry. the ore has been opened by drift and shaft, showing about 3 feet of ore of the following composition.

Analysis of Ore from Drift on Ridge south of Tumlin Gap. Sampled by the writer, analysed by Ernest Sifford. Pile of 75 tons.

	Per Cent.
Metallic iron	49.39
Silica	5.60
Alumina	4.31
Lime	7.15

Above this drift and communicating with it is a shaft about 50 feet deep, showing from 2 to 3 feet of ore of the following composition. Analysis of Ore from Shaft on Ridge south of Tumlin Gap. Sampled by the writer, analysed by Ernest Sifford. Pile of 50 tons.

	Per Cent.
Metallic iron	53.72
Silica	6.80
Alumina	5.02
Lime	2.26

The exploitation of the Greasy Cove ore in depth, by means of drill holes located back of the outcrop, is now in progress.

The Red Mountain formation in Greasy Cove has been somewhat disturbed by faults and overlaps, but there is good reason for believing that workable seams of ore, both soft and hard, are to be found here.

Shelby County.

The existence of the Red Mountain formation in this county has not yet been determined. It is certainly lacking over the greater part of the county and if present at all it is in small, isolated patches.

Talladega County.

The Red Mountain formation in this county occurs in the northwest corner. It is of only a few feet in thickness and covers a small area, thought to be less than one square mile.

Tuscaloosa County.

The Red Mountain formation in this county is from 150 to 400 feet thick and may cover an area of as much as 10 square miles.

As this formation extends southwesterly from its great development in Jefferson county it is a matter of considerable commercial importance to know whether the workable seams of ore also occur in this county. There is only one place at

which the ore is mined in Tuscaloosa county, viz., about 2½ miles south of Dudley, a station on the Alabama Great Southern Ry.*

The Gray, or So-Called Magnetic Ores.

DISTRIBUTIONS, SECTIONS, AND ANALYSES, ETC.

These ores have been more particularly described by Mr. John S. Grasty (Manufacturers' Record, Baltimore, May 31, 1906) and Dr. Philip S. Smith (Bulletin No. 315, Contributions to Economic Geology, United States Geological Survey, Washington, 1906.) The following account of these ores is abstracted from these papers, with some additional data. The deposits were mentioned by Tuomey in 1858 but it was not until 1904 that the production of this variety of hematite was given as a separate item. In that year the output was 17,944 tons and in 1905 26,857 tons, classed as magnetite.

The ores appear to be held in the Weisner quartzite and sandstones of the lower Cambrian. which attain in this State a thickness of 2 500 feet. So far as known at present the workable ores are confined to the northern and northeastern part of

*These developments are being carried on by the Big Sandy Iron and Steel Company in sections 8, 17 and 19 of Township 22, Range 7 West.

From Bulletin No. 600 of the United States Geological Survey, we give the following notes of this property: "A railroad spur has been built from the Alabama Great Southern R. R. south—southeast 1.8 miles to the tipple at slope No. 1. The beds dip S. 65 E. at angles varying from 12 to 14 on the outcrop, through a place where the dip is about 10, beyond which they dip 17 to 18. In January, 1909, this slope had been driven about 1,050 feet, with about 12 headings at the left and right. Ore had recently been mined from a bed yielding about 6½ feet of ore from a total thickness of 10 to 12 feet of ore-bearing beds. Drilling was done by compressed air, and the equipment of the mine is capable of handling a large output of ore.

Hard ore from this slope carries 30 to 36 per cent. iron, 19 to 28 per cent. silica, 6 to 10 per cent. alumina, and 8 to 20 per cent. lime.

Several thousand tons of ore were shipped from here to the furnaces of the Tennessee Company in the summer of 1907.

"Mr. Burchard gives a number of analyses of the ore from this slope No. 1 and for further details of this, the southernmost point at which any development of the red ore has been done in the Birmingham Valley, the reader is referred to the report above mentioned.

The ore-bearing formation extends a few miles southwest beyond Big Sandy Creek, but is soon covered by the unconsolidated beds of the Coastal Plain E.—(E. A. S.)

Talladega county and in this county the Weisner formation covers, according to Henry McCalley, not more than 50 square miles of surface area. "It is confined to the outlying mountains, viz: Sulphur and Chalybeate Springs Mountains, Katala Mountains, Kahatchee, Andeluvia (Pope), Wewoka, Alpine and Talladega. These mountains are broad, and broken and have many points that are from 500 to 1000 feet higher than the surrounding country. They are just to the southeast of faults, or are of the southeast halves of faulted anticlinals, and their high points are principally the crests of waves with northwest and southeast trends." (Henry McCalley, Valley Regions of Alabama, Part II p. 542, Ala. Geol. Survey, 1897.)

The ore district lies north of the town of Sylacauga and is penetrated by the Central of Georgia Railroad and the Louisville & Nashville Railroad.

There are two well recognized districts, Tallasseehatchee and Wewoka, most of the development, so far, having been confined to the former. The thickness of the seams shows considerable variation, from 3 to 40 feet, and the composition of the ore also shows marked differences. The two best analyses given by Mr. Grasty are of the two highest beds on Heacock Mountain, in the Wewoka district. These are as follows:

Analyses of Gray Ore from Heacock Mountain, Talladega county. Analyst, C. Glaser, Baltimore.

	Top Bed	Middle Bed
Metallic iron	56.31	54.95
Silica	15.29	16.26
Alumina	3.26	2.90
Lime	1.26	0.98
Magnesia	None	None
Titanium oxide	1.18	0.40
Arsenic	0.31	0.17
Potash	Trace	Trace
Phosphorus	0.12	0.013

These analyses represent the high water mark for this class of ore.

The ore as shipped carries about 45 per cent. of iron with silica from 25 to 28 per cent. Some other analyses of these ores show a content of potash from 1.24 to 3.93 per cent.

In this connection there may be given a detailed analysis of this gray ore from the Tallaseehatchee district made by Mr. R. S. Hodges on samples collected by Dr. Philip S. Smith, of the United States Geological Survey. This analysis is as follows:

Analysis of Gray Ore collected by Dr. Philip S. Smith, of the United States Geological Survey, Tallasseehatchee Mine. Analyst, R. S. Hodges.

	Per Cent.
Silica	28.30
Alumina	4.50
Ferric oxide	59.94
Ferrous oxide	1.79
Manganese oxide	0.04
Calcium oxide	0.53
Magnesium oxide	0.26
Sodium oxide	0.22
Potassium oxide	2.08
Lithium oxide	Trace
Arsenic trioxide	0.031
Copper oxide	0.026
Nickel oxide	0.02
Cobalt oxide	0.02
Vanadium oxide	0.044
Molybdenum oxide	Trace
Titanium di-oxide	0.24
Phosphoric acid	0.95
Sulphur	0.09
Water on ignition	1.30
	100.381
Metallic iron	43.34
Phosphorus	0.41

This analysis shows an ore of complex composition, for in addition, to the usual constituents of iron ores it reveals the presence of potash, lithium, arsenic, copper, nickel, cobalt, vanadium and molybdenum. Titanium is present in nearly all of the ores used in Alabama but in small amounts. Its presence is revealed in the masses of titanium nitro cyanide which accumulate in the hearth of the blast furnaces.

Some of the analyses given of these ores show a low phosphorus content, 0.013 per cent., but others, on the contrary, show that this ingredient may and often does exist in amounts

up to 0.4 per cent. With such extreme variation it is not likely that these deposits can be utilized in the production of Bessemer iron.

These ores are sometimes slightly magnetic and occasionally they exhibit decided magnetism. Some experiments were made by the writer to determine whether the admixed silica could be separated from the iron-bearing portions of the ore, but they were not successful. It is possible that with a machine of the Wetherill type lower grade ores could be successfully concentrated, but they would have to be crushed fine and the concentrates briquetted or sintered.

The gray ore district may, it is thought, be depended on to supply a large amount of ore that would carry from 43 to 46 per cent. of iron, with 25 to 28 per cent. of silica and 3 per cent. of alumina. The quality would thus be closely similar to that of ordinary soft red ore. If the supply of brown ore (limonite) should be markedly decreased it is likely that these ores would find a much wider and larger market. Some kind of siliceous ore is demanded for mixing with the limy ore, the soft red ore being used for this purpose and even the more siliceous of the brown ores. It is believed that the gray ores will ultimately come into market on a much larger scale than at present, but it will not be until the supply of soft red ore and of brown ore is materially diminished.

The gray ore works well in the furnace and there is no reason, save that of cost, why it should not be used extensively. The deposits lie within 40 miles of Birmingham and within 30 miles of Anniston, and are within easy touch of two railroads.

These ores were first classed as magnetites in the statistics of production but are now considered as hematites. Nearly all of them show a slight natural magnetism.

Production of Hematites in Alabama.

The yearly production of red hematite, in Alabama, since 1889 is given in the following Table, taken from the reports made by Mr. John Birkinbine to the United States Geological Survey.

TABLE III.—*Production of Red Hematite Ore in Alabama since* 1887. *Tons of* 2240 *lbs.*

1889	1,190,985
1890	1,538,297
1891	1,524,783
1892	1,657,028
1893	1,281,292
1894	1,182,362
1895	1,830,987
1896	1,694,648
1897	1,738,583
1898	1,853,111
1899	1,911,097
1900	1,989,689
1901	2,070,422
1902	2,565,635
1903	2,779,691
1904	2,894,423
1905	2,974,413
1906	3,173,797
1907	3,144,011
1908	2,775,903
1909	3,176,416
1910	3,678,139
Total,	51,625,712

An estimate for the nine years, 1880-1888 would increase this total product by about three million tons, making a total of 54,625,712 tons during the thirty years, 1880-1910.

CHAPTER III.

THE ORES—SPECIAL DISCUSSION—(Continued.)

The Limonites, or So-Called Brown Ores.

GENERAL DESCRIPTION AND PREPARATION.

As a rule this ore constitutes the best material for iron making in the State. Practically all of the charcoal iron is made from brown ore and although there has been a marked decrease, of recent years, in the production of charcoal iron in Alabama, following the general tendency in the country at large, the total amount made in the State from 1872 to the close of 1906 was 1,739,806 gross tons, requiring about 3½ million tons of ore. During the years 1904 and 1905 there were produced in Alabama 7,482,712 tons of iron ore of which 1,569,075 tons, or a trifle under 21 per cent. was brown ore. During this same period the production of charcoal iron was 51,378 tons and if we allow 2.13 tons of ore per ton of iron the consumption of brown ore for charcoal iron was 109,435 tons. Subtracting this from the 1,569,075 tons of total production we have 1,459,640 tons of brown ore entering into the production of 3,227,332 tons of coke iron in 1904 and 1905. Taking the average content of iron in the brown ore as thus used at 47 per cent. (2.13 tons per ton of iron) we have 685,277 tons of coke iron produced from the brown ore mined during the years 1904-05, or 9.14 per cent. The proportion now is somewhat greater, so that about 10 per cent. of the coke iron now made is derived from brown ore. This proportion is likely to increase, not only because of the enlarging demand for brown ore but also because the use of brown ore increases the amount of manganese in the pig iron and many foundrymen, etc., are asking for manganese in the iron.

The brown ore deposits do not occur in regular veins, except such as form the gossan of underlying pyritiferous veins, but as pockets in clay. These pockets are of quite variable extent, both laterally and vertically, and each one has to be judged for itself alone. They do not appear to follow any known law

of deposition and it is a common saying that no one has much knowledge of a brown ore "bank" beyond the length of his pick.

The ore is of two sorts, lump and gravel. The lump ore is generally better than the gravel ore unless the latter is well washed from adhering clay. But the presence of chert, or sandy inclusions, in the lump ore, as also the clay-filling of the interstices and small holes, sometimes makes the lump ore objectionable. The lumps vary in size from that of the fist to several tons in weight. They are broken up and loaded without further treatment. By far the greater part of the brown ore is in size between that of a pigeon's egg and a goose egg. Excluding the large lumps, the method of winning the brown ore is briefly as follows:

The "bank" is cut away in benches, the entire mass being taken down either by hand or by steam-shovel. The material is loaded on trams and conveyed to ordinary log washers, single or double, as the case may be, where it is subjected to a thorough washing and stirring in large excess of running water. The clay is removed by suspension in water and is often run into settling dams for the recovery of the water.

The material from the log-washer is discharged into screens, in which play several streams of water, for the purpose of removing the sand and small particles of ore from the lump ore. The lump ore then goes to a picker-belt and the sand and fine ore to jigs. In the jigging of this mixture of sand and fine ore there is room for great improvements. At some washeries there is a heavy loss of ore.

Where the clay holding the gravel is friable and does not "ball" under the action of the water and the screens this method of washing is sufficient. There is considerable variation in the character of the clay. some of it being easily disintegrated, yielding its ore readily, while other clays are tenacious and putty-like. In this case there may be serious loss of the finer particles of ore, the balls of clay picking them up, enwrapping them and finally carrying them off into the waste dump. At some washeries the clay balls are removed by hand.

The value of a brown ore "bank" depends not only upon its content of ore of shipping grade, but also and particularly upon the nature of the enclosing clay. The practical yield is influenced by the case with which the clay can be removed.

A method of washing which has given good results is to discharge the trams into a head-box in which play two or more streams of water under pressure. The lower end of the box, which is of triangular shape and inclined about 30 degrees, opens into a long wooden trough lined with castings of iron fitted snugly to the bottom. This trough, in turn, discharges into the washer at the foot of the hill.

The advantages claimed are the violent agitation of the mass with water delivered under pressure and the better separation of the clay from the ore in tumbling down the long trough. The moderately tenacious clays may be removed in this manner, but with the more tenacious clays even this procedure is not altogether satisfactory. In fact it rather tends to increase the "balling." The friable and more easily disintegrated clays, on the contrary, are speedily removed and the washer is called on merely to complete a process which is already well advanced.

This system of washing may appropriately be termed the modified placer. The amount of material to be moved and washed, per ton of ore, varies within wide limits and is quite beyond any general statement. Even the same "bank" shows considerable differences in this respect. It is a matter which can not be determined before-hand and is liable to change from day to day.

The amount of water brown ore may contain, irrespective of the water of combination, varies according to circumstances. If the washer is so near the furnace that the water has not time to drain from the cars there will be more water than if the haul were longer. So also if the ore be not properly washed, the clay still remaining will hold water. With a haul of 25 to 50 miles and under ordinary weather conditions well washed brown ore will contain 7 per cent. of moisture when delivered at the furnace. This moisture is not to be confused with the water of combination, the water that enters into the brown ore as an invariable constitutent and which can not be removed under a dull red heat. Normal limonite, when pure, contains 14.44 per cent. of this combined water (water of constitution) and 85.5 per cent. of oxide of iron (=59.89 per cent. of metallic iron). Its chemical formula is written:

$$2\ Fe_2O_3 . 3\ H_2O.$$

The water it contains (not to be confused with ordinary wetness) is not driven off under a dull red heat. With this water removed the ore becomes hematite and contains 70 per cent. of metallic iron.

There are two kinds of water in brown ore, the ordinary moisture of the atmosphere, given off at boiling heat, and the water of combination, given off at red heat. If a sample of brown ore be thoroughly dried it will still be found to contain its water of combination, and when this water is removed, at red heat, it can not again enter into the ore as a requisite constituent. Normally, brown ore, when pure, contains, as before stated, 14.44 per cent. of combined water, but may contain up to 16 per cent.

An average analysis of a good quality of brown ore, as delivered to the furnaces in Alabama, is as follows:

	Per Cent.
Hygroscopic water	7.00
Combined water	6.00
Metallic iron	48.54
Silica	11.22
Alumina	3.61
Lime	0.84
Phosphorus	0.38
Sulphur	0.09

If this ore was pure it would contain no hygroscopic water, no silica, alumina, lime, phosphorus or sulphur. It would consist merely of combined water and oxide of iron.

Selected brown ore may carry as much as 56 per cent, of metallic iron and in some instances, in this district, even more. At one establishment the ordinary ore, as charged, carries 53 per cent. of iron, after washing and calcining. If the ore, the analysis of which has just been given, had been calcined, before going to the furnace, there would have been removed the hygroscopic water and the combined water, amounting to 13 per cent. and the content of metallic iron would have risen from 48.54 to 55.66 per cent. But calcining has not been generally practiced in Alabama, the rule being to send the ore direct to the stock-house from the washer.

Well washed brown ore, free from clay, seldom contains more than 4 per cent. of moisture and the increase in the

moisture above this amount follows closely upon the increase in the amount of clay.

There is a circumstance in connection with the use of brown ore that merits attention, not only because of its contradistinction to soft red ore but also and particularly because of its bearing on questions of concentration, whether by simple screening or by some magnetic process, such as the Wetherill or the Payne. It has been stated that even the lower grades of soft red ore on being dried and ground to pass a 10-mesh screen carry much more iron in the material passing a fine screen (40 to 50 mesh) than in the coarser stuff. In such ores there is a marked increase in the iron the finer the screen, up to and including a 50-mesh. This is not true in respect to the brown ore. The finer the screen, up to and including a 50-mesh, the less iron does the material passing the screen contain.

Not only have laboratory experiments shown this to be true but actual work on a large scale has substantiated the general truth of the proposition that on crushing brown ore, whether by machines or by the attrition of the burden in a kiln, the fine material carries less iron than the coarse.

Attention is called to this matter because of the practice, at some kilns, of drawing the ore over screens to the furnace buggies. There is considerable loss of material, in this practice, and it is not to be recommended unless the ore carries an unusual amount of clay. It may happen that as much as 10 per cent. is lost, even over a half inch screen.

Some experiments were undertaken to establish the actual loss and what content of iron was present in the different sizes, Several hundred pounds of ore were taken, the samples being drawn over several days and put together, so as to secure a fair average. The results of the analyses were as follows:

	Iron.	Silica.
Raw Ore	44.63	13.82
Calcined ore	50.20	15.10
Calcined ore—		
On ¼-inch screen (68%)	52.95	10.25
Through ¼-inch screen (32%)	49.30	15.90
On ⅛-inch screen (77%)	52.75	11.05
Through ⅛-inch screen (23%)	42.85	21.80

It can not, of course, be said that all varieties of brown ore act in this manner, but the ore examined was representative of a large amount of ore that was then being used.

Screening over a quarter inch screen gave 68 per cent. on the screen, with 52.95 per cent. of iron, and 32 per cent. through the screen, with 49.30 per cent. of iron. Screening over an eighth inch screen gave 77 per cent. on the screen, with 52.75 per cent of iron, and 23 per cent. through the screen, with 42.85 per cent of iron.

Screening this kind of ore can not be recommended, except for material carrying much clay and this should be removed in the washer. There is practically but little difference between the "overs" on a quarter inch and eighth inch screen with respect to the metallic iron. but there is difference of 9 per cent. in weight in favor of the coarser screen. The loss through either screen is too large for profitable work, except under conditions requiring the use of the best ore obtainable. The beneficiation of the brown ores is discussed in the chapter on Concentration of Ores.

GEOLOGY.

For the data in regard to the geological relations of the brown ore acknowledgement is freely and gratefully made to the reports on The Valley Regions of Alabama, 1897, by Henry McCalley, Assistant State Geologist. The material, occupying the following pages down to the statistics of production, is adopted from his reports.

For further discussion of the Alabama brown ores the reader is referred to a series of articles published by the writer in the Iron Age, N. Y., June 4, 11, 25, July 9; August 6 and September 3, 1908. Reference is also made to the articles by Mr. E. F. Burchard, F. W. Hausmann and E. Higgins mentioned in the introduction.

The geological formations in the State which carry limonite, or brown ore, are the following:

Crystalline—Talladega Slates. In Talladega county. In Calhoun county this formation extends over 20 square miles and contains beds of limonite not yet worked. These slates also occur in Coosa county, and in Chilton county they cover an area of 75 to 80 square miles. The Clear Creek deposits, Chilton county, belong here. These slates are crystalline and were long held to belong to the older rocks. Since the discovery of Carboniferous fossils, however, near Moseley, Clay county, the age of at least a portion of them must be referred to a later date.

Cambrian—Weisner (Chilhowee) Sandstone. The total thickness of this formation in the State is about 3,000 feet. In Calhoun county it attains a thickness of more than 2,500 feet and covers an area of about 59 square miles. The extensive brown ore "banks" near Anniston may be referred here, although some of them may belong to the overlying Montevallo. The deposits known as the Bob Garrett, Landrum, Leach, Pruett, Woodstock, Skinner, Washer, Old Field, Nichols, Blackburn, Dunn, Thompson, Scarborough, etc. lie partly in the Weisner and partly in the Montevallo, as there seems to be no very well marked line of demarkation between them.

In Cherokee county the Weisner sandstone attains a thickness of more than 2,500 feet and contains some deposits of

brown ore not now worked. In this county the area covered by the Weisner sandstone is about 30 square miles.

In Cleburne county the Weisner sandstone covers an area of about 45 square miles and contains brown ore not yet worked.

This formation is also seen in Talladega county, but the beds of brown ore are not yet worked.

Cambrian—Montevallo (Variegated) Shale and Sandstone, and Aldrich Limestone (Hayes' Lower Conasauga, Rome Formation, and Beaver Limestone). The thickness of this formation in the State varies from 1,200 to 3,000 feet.

In Calhoun county the thickness is from 1,500 to 2,500 feet and it covers an area of about 150 square miles. As already remarked, the brown ore deposits near Anniston, which have been extensively worked and have yielded much good ore, are to be referred to this formation and the underlying Weisner sandstone.

In Shelby county this formation is from 1,500 to 3,000 feet thick and covers an area of about 50 square miles. The famous brown ore "banks" at Shelby, long used by the Shelby Iron Company in the production of its excellent charcoal iron, lie on the eastern edge of this formation above strata which are at the bottom of the Knox Dolomite (Lower Silurian).

The Montevallo also occurs in Talladega county, of a thickness approximating 3,000 feet and covering an area of about 200 square miles. The brown ore it contains is not now worked.

Cambrian.—Coosa (Flatwood) Shales, Hayes' Conasauga. This formation is more than 1,800 feet thick in this State. The brown ore deposits around Woodstock, Bibb county, and Goethite, Greeley, &c. Tuscaloosa county, may be referred here and to the Knox Dolomite (Lower Silurian) and the Tuscaloosa formation of the Cretaceous. They overlie the Coosa Shales and Limestones.

The deposits known as the Edwards, Greeley, Goethite, Eureka, Williamson, Greenpond, &c., present almost the same general features and are to be regarded as of closely similar origin. The overlying Lafayette of the Tertiary, is practically barren of ore.

The thickness of the Cambrian in this State which contains brown ore deposits is between 7,000 and 7,500 feet and the area

BAKER HILL BROWN ORE BANK, CHEROKEE COUNTY.
TECUMSEH IRON COMPANY.

MARION STEAM SHOVEL, CENTRAL WASHER BROWN ORE BANK, CHEROKEE COUNTY. TECUMSEH IRON COMPANY.

involved is 540 square miles of which the Weisner has 125, the Montevallo 400 and the Coosa about 15 square miles. It is not known how much workable ore is represented by this area.

Lower Silurian—(Ordovician)—Knox Dolomite, (including Hayes's Upper Conasauga) The thickness of this formation in the State is from 2,000 to 4,000 feet. The total area is about 1,500 square miles. In Bibb county the thickness is from 2,000 to 3,000 feet and the area covered is about 40 square miles. The Bright Hope deposits are in this formation. The deposits around Woodstock, Goethite, Greeley, &c., as already observed, are to be included here and in the Coosa shales of the Cambrian.

In Blount county about 30 square miles in the broken central portion of Murphree's Valley are referable to this formation, including the Champion mines which have produced large amounts of excellent ore. In Calhoun county the thickness of this formation is from 3,000 to 4,000 feet, the area covered being from 175 to 200 square miles. The deposits known as Windom, Walker, Edmundson, Pine Grove Church, Leatherwood, Cooper, &c., belong here.

In Cherokee county the thickness of the Knox Dolomite is from 3,000 to 4,000 feet and the area covered is about 150 square miles. The deposits known as Weems, Dyke, Taylor, Carr, Washer, Baker Hill, McClung, &c., are in this formation. Plates VIII and IX.

Chilton county contains about 12 square miles of this formation, but furnishes, as yet, no ore.

Cleburne county contains some 3 square miles of the formation and the Tibbs, Brewster, &c., deposits belong here.

In DeKalb county the thickness is 2,500 feet and the area involved is about 55 square miles.

In Etowah county the thickness ranges from 2,000 to 2,500 feet and the area is 100 square miles. The Robt. Jelkes deposit (northwest base of Colvin mountain) is in this formation.

Jackson county contains 80 square miles of this formation, with a thickness of 2,000 feet.

In Jefferson county there are 50 square miles with a thickness of 2,000 to 3,000 feet.

In Marshall county there are two small areas.

In St. Clair county there are 140 square miles, with a thickness of 2,000 to 3,000 feet. The deposits near Seddon, on the Southern Ry., are to be referred here.

In Shelby county there are 200 square miles, with a thickness of 3,500 to 5,000 feet. The famous deposits at Shelby rest on the bottom of the Knox Dolomite.

This formation is largely developed in Talladega county, with 400 square miles and a thickness of 3,000 to 4,000 feet. To this formation are to be referred the following deposits, viz: Singleton, Ledbetter, Flournoy. Welch, Reynolds and Whiting, Carlton, Webb, Weisinger, Jones, Seay, Irona, Hurst, Pace, Leonard, Logan, Washer, Dye, Curry (Fox), Parker, Poorhouse, &c. These ores have been used in the furnaces at Ironaton and Jenifer.

Tuscaloosa county has about 15 square miles, with a thickness of 2,000 to 2,500 feet. The deposits around Greeley &c., belong here, as also in the Coosa shales (Cambrian), as already observed. Plates X, XI and XII.

Lower Silurian.—Pelham Limestone. (Trenton, Chicamauga, Rockmart Slates). This formation yields but little brown ore. Its thickness varies from 600 to 1,800 feet. Jackson county has about 30 square miles, with a thickness of 700 to 900 feet, but no ore is mined there.

The Lower Silurian which furnishes brown ore has a total thickness in the State of about 6,000 feet and the total area in the counties which are known to contain this ore is 1,480 square miles, of which 1,450 belong to the Knox Dolomite and 30 to the Pelham Limestone. It is not known how much workable ore is represented by this area.

Upper Silurian.—Red Mountain (Clinton). In Jackson county this formation has a thickness of 200 to 225 feet and covers an area of 15 square miles. It contains some deposits of brown ore which have not yet been worked. There are other isolated patches of brown ore throughout the Red Mountain formation, but they do not seem to be of commercial importance.

Lower Sub-Carboniferous.—Fort Payne, Lauderdale or Keokuk Chert. Thickness in the State 600 feet. In Bibb county this formation has a thickness of 50 to 175 feet and covers an area of 8 to 10 square miles.

In Blount county it has a thickness of 175 to 225 feet and an area of 20 square miles.

No. 4 Washer and Tipple, Tannehill Brown Ore Mine, Goethite, Tuscaloosa County.
Republic Iron and Steel Company.

In Calhoun county the thickness is 25 to 150 feet and the area is 30 square miles.

In DeKalb county the thickness is 200 to 300 feet and the area 35 square miles.

In Etowah county the thickness is 150 to 275 feet and the area is 15 square miles. The ore is associated here with manganese ores.

In Jackson county the formation is 100 to 150 feet thick and the area 50 square miles.

In Jefferson the thickness is 250 to 300 feet and the area is 30 square miles.

In Lauderdale county this formation reaches its greatest development, with a thickness of 175 to 250 feet and an area of 450 square miles. The O'Neal deposit belongs here. Also in Limestone county the development is heavy, with a thickness of 175 to 225 feet and an area of 100 square miles.

In Marshall county the formation has a thickness of 150 to 185 feet and an area of 15 square miles.

In St. Clair county the thickness is 150 to 275 feet and the area 35 square miles.

In Shelby county the thickness is 0 to 150 feet and the area is 15 to 20 square miles.

The total area in this formation which is known to carry brown ore is about 1,100 square miles, but it is not known how much workable ore is represented.

Upper Sub-Carboniferous—Oxmoor, or Shale and Sandstone Phase; Bangor, or Limestone Phase, Hartselle Sandstones. Thickness in the State about 2,600 feet.

In Bibb county the thickness is 600 to 1,000 feet and the area covered is 10 square miles.

In Chilton county there is an area of 17 square miles.

In Franklin county there is an undefined area around Franklin Springs.

In St. Clair county the thickness is 800 to 1,500 feet and the arear is 120 square miles.

In Shelby county the thickness is 1.200 to 1,800 feet and the area is 250 square miles.

In Jefferson county the thickness is from 800 to 1,500 feet, and the area about 135 square miles.

The ore-bearing area in this group is about 400 square miles, but it is not known how much workable ore is represented.

Carboniferous.—Coal measures. Thickness in the State 5,500 to 6,000 feet.

In Cherokee county the thickness is 400 feet and the area is 150 square miles.

In DeKalb county the thickness is 600 feet and the area is 600 square miles.

In Franklin county the thickness is 250 feet and the area is 150 square miles. The Rockwood deposit belongs here.

In Jefferson county the thickness is 2,000 to 2,500 feet and the area is 700 square miles.

In Marshall county the thickness is 325 feet and the area is 325 square miles. The Ridgway deposit belongs here.

In Tuscaloosa county the thickness is 4,000 to 5,000 feet and the area is 360 square miles.

The ore-bearing area of the Coal Measures is 2,285 square miles but it is not known how much, if any, workable ore is represented.

Cretaceous—Tuscaloosa. Thickness not yet known

In Bibb county there is an area of 415 square miles. The deposits around Woodstock are partly in the Tuscaloosa, partly in the Knox Dolomite and partly in the Montevallo. They belong thus to the Cretaceous, the Lower Silurian and the Cambrian.

In Tuscaloosa county the area of the Tuscaloosa is about 745 square miles.

The ore-bearing area of the Tuscaloosa formation is about 1,160 square miles, but it is not known how much workable ore is represented.

Tertiary, or later Lafayette.—Thickness not yet known.

In Bibb county there is an area of unknown extent. The deposits here may belong to the Lafayette, or to some earlier formation. The ore a mile west of Scottsville is a case in point.

In Colbert county the area involved is about 290 square miles. The deposits known as the Wingo and the Linewood belong here.

In Franklin county the area involved is about 460 square miles. The Russellville and Parish deposits belong here.

In Lauderdale county the thickness is 80 feet and the area is 125 square miles.

In Lawrence county there is some brown ore in the Lafayette.

East Giles Brown Ore Pit, Greeley, Tuscaloosa County. Tennessee Coal, Iron and Railroad Company.

HOUSTON BROWN ORE MINE, RENO, TUSCALOOSA COUNTY. STRIPPING SHOVEL ON UPPER BANK. REPUBLIC IRON AND STEEL COMPANY.

In Shelby county, on Camp Branch and in the southern part of T. 22 S. R. 1 E., two miles west of the Coosa river, there is an area which carries ore and may belong to the Lafayette.

In Tuscaloosa county there a little good ore in the Lafayette, but the commercial outlook is not favorable.

The area of the ore-bearing Lafayette is not known nor how much workable material is represented.

Resumè of area involved in Brown Ore Deposits.

	Square Miles.
Crystalline	100
Cambrian—Weisner, 125; Montevallo, 400; Coosa, 15	540
Lower Silurian—Knox Dolomite, 1,450; Pelham, 30	1,480
Upper Silurian—Red Mountain	15
Lower Sub-carboniferous—Fort Payne, Lauderdale, Keokuk	1,100
Upper Sub-carboniferous—Oxmoor, Bangor, Hartselle	400
Carboniferous—Coal measures	2,285
Cretaceous	1,160
Tertiary	—
	7,080

In explanation of this it must be said that while the brown ores are found in the formation that cover an area of 7,080 square miles it is not meant that they are found over this entire area. The exact extent of the workable brown ores in this State is unknown and one is not warranted in giving even an approximate estimate of the reserves of brown ore. The best known deposits are so variable in their content of ore that it is hardly possible to express an opinion concerning them. An experience of more than twenty years with this class of ore in many of the southern States has forced this conviction upon the writer and while he regrets that he can not share the opinions of other observers, with reference to the possibility of estimating brown ore reserves, yet in the face of accumulated facts he can take no other view of the matter.

In the following list an attempt has been made to enumerate the brown ore deposits in the State which are now being used and which may be found hereafter to yield sufficient workable ore to be of commercial importance.

Some of these may hereafter be found to be more closely associated with Cambrian rocks (Weisner, Montevallo, Coosa) than with the Knox Dolomite. The line of separation is not always apparent. The decay of the older rocks has often left the ore deposits which they contained so mingled with the later formations that it is a difficult matter to differentiate between them. The point is more academic and scientific than practical. The obligations of the writer to the two excellent reports of Henry McCalley (The Valley Regions of Alabama, Ala. Geol. Survey, 1897) is freely acknowledged. In the death of Mr. McCalley, the State lost one of the most intelligent, industrious and painstaking observers in the field. The nomenclature adopted is that of the Alabama Geological Survey.

TABLE IV.—*Alphabetical List of Brown Ore Deposits in Alabama.*

NAME	COUNTY	GEOLOGICAL FORMATION
Adair	Talladega	Knox Dolomite.
Adams & Green	Talladega	Knox Dolomite.
Ala. Min. Land Co.	Talladega	Knox Dolomite.
Alexander	Calhoun	Knox Dolomite.
Allen	Franklin	Lafayette.
Baker	Talladega	Knox Dolomite.
Baker Hill	Cherokee	Knox Dolomite.
Bales	Talladega	Knox Dolomite.
Bibb Furnace	Bibb	Tuscaloosa-Lafayette.
Bishop	Talladega	Knox Dolomite.
Black	Franklin	Lafayette.
Blackburn	Calhoun	Montevallo-Weisner.
Bluffton	Cherokee	Weisner
Bluff Creek	Lauderdale	Lauderdale.
Boaz	Talladega	Knox Dolomite.
Brewer	Talladega	Knox Dolomite.
Brewster	Cleburne	Knox Dolomite.
Bright Hope	Bibb	Tuscaloosa? Lafayette?
Bruce	Talladega	Knox Dolomite.
Buchanan	Calhoun	Knox Dolomite.
Burke	Talladega	Knox Dolomite.
Burt	Talladega	Knox Dolomite.
Caffee's Creek	Bibb	Knox Dolomite.
Cane Creek	Calhoun	Fort Payne Chert.
Camp	Talladega	Weisner or Knox Dolomite.
Carlton	Talladega	Knox Dolomite. Overlies Coosa.

Alphabetical List of Brown Ore Deposits—Continued.

NAME	COUNTY	GEOLOGICAL FORMATION
Carr	Cherokee	Knox Dolomite
Cedar Creek	Franklin	Lafayette.
Clark	Calhoun	Knox Dolomite.
Clay	Cherokee	Weisner.
Clear Creek	Chilton	Crystalline.
Clements	Calhoun	Knox Dolomite.
Clifton Iron Co.	Talladega	Knox Dolomite.
Cook	Talladega	Knox Dolomite.
Cooper	Calhoun	Knox Dolomite.
Curry	Talladega	Knox Dolomite.
Dry Valley	Talladega	Knox Dolomite.
Duncan	Talladega	Knox Dolomite.
Dunkin	Talladega	Knox Dolomite.
Dunn	Calhoun	Montevallo Weisner.
Dye	Talladega	Knox Dolomite.
Easta Boga	Talladega	Weisner, or Knox Dolomite.
Edmundson	Calhoun	Knox Dolomite.
Edwards	Tuscaloosa	Tuscaloosa, Lafayette. Overlies Coosa.
Elliott	Talladega	Knox Dolomite.
Ensley	Franklin	Lafayette.
Eureka	Tuscaloosa	Tuscaloosa, Lafayette. Knox Dolomite. Overlies Coosa.
Flournoy & Welch	Talladega	Knox Dolomite.
Fox	Talladega	Knox Dolomite.
Frog Mountain	Cherokee	Knox Dolomite.
Galant Creek	Tuscaloosa	Tuscaloosa.
Garner	Talladega	Knox Dolomite.
Garrett	Calhoun	Weisner, Montevallo.
Gladden	Calhoun	Knox Dolomite.
Glaziner & Barnet	Talladega	Knox Dolomite.
Goethite	Tuscaloosa	Tuscaloosa, Lafayette. Knox Dolomite. Overlies Coosa.
Greeley	Cherokee	Weisner.
Greelley	Tuscaloosa	Tuscaloosa, Lafayette. Knox Dolomite Overlies Coosa
Greenpond	Bibb	Tuscaloosa, Lafayette. Knox Dolomite. Overlies Coosa.
Gross	Talladega	Knox Dolomite.
Hamilton	Talladega	Knox Dolomite.
Hancock	Talladega	Montevallo.
Hardee & Russell	Talladega	Knox Dolomite.
Haslett	Talladega	Knox Dolomite.
Heacock	Talladega	Knox Dolomite.

Alphabetical List of Brown Ore Deposits.—Continued.

NAME	COUNTY	GEOLOGICAL FORMATION
Hendrick	Talladega	Knox Dolomite.
Hepzibah Church	Talladega	Knox Dolomite.
Hewitt	Calhoun	Montevallo.
Hewitt	Talladega	Knox Dolomite.
Hickman	Talladega	Knox Dolomite.
Hickory Tree	Cherokee	Weisner.
High Bluff	Cherokee	Weisner.
Hockins	Calhoun	Knox Dolomite.
Hurst	Talladega	Knox Dolomite.
Huston	Talladega	Knox Dolomite.
Irona	Talladega	Knox Dolomite.
Ironaton	Talladega	Knox Dolomite.
Janey Furnace	Calhoun	Fort Payne Chert.
Jelkes	Etowah	Knox Dolomite.
Jenifer	Talladega	Knox Dolomite.
Jilkes	Calhoun	Knox Dolomite.
Jones, Tom	Talladega	Knox Dolomite.
Keith	Talladega	Knox Dolomite.
Landrum	Calhoun	Weisner Montevallo.
Laney	Calhoun	Knox Dolomite.
Laney	Cherokee	Weisner
Laney & Piedmont	Calhoun	Sub-carboniferous. Fort Payne Chert.
Langdon (Stonewall) Furnace	Cherokee	Weisner.
Langford	Calhoun	Knox Dolomite.
Lanier	Talladega	Knox Dolomite.
Lawson	Talladega	Weisner.
Leach	Calhoun	Weisner, Montevallo.
Leatherwood	Calhoun	Knox Dolomite.
Ledbetter	Talladega	Knox Dolomite.
Lennard	Talladega	Knox Dolomite.
Lewis	Talladega	Knox Dolomite.
Linewood	Colbert	Lafayette.
Logan	Talladega	Knox Dolomite.
McClung	Cherokee	Knox Dolomite.
McPherson	Talladega	Weisner.
Mallory Mountain	Talladega	Weisner. Knox Dolomite.
Martin & Gooch	Talladega	Knox Dolomite.
Mechanic	Bibb	Tuscaloosa, Lafayette.
Miller	Talladega	Knox Dolomite.
Mims	Talladega	Knox Dolomite.
Monahan	Calhoun	Fort Payne Chert.
Munford	Talladega	Weisner. Knox Dolomite.
Nevins	Talladega	Knox Dolomite.
Nichols	Calhoun	Montevallo. Weisner.
Old Field	Calhoun	Montevallo. Weisner.

Alphabetical List of Brown Ore Deposits.—Continued.

NAME	COUNTY	GEOLOGICAL FORMATION
Ogletree & Grady	Talladega	Knox Dolomite.
Ogletree & Story	Talladega	Knox Dolomite.
Old Tram	Talladega	Knox Dolomite.
O'Neal	Lauderdale	Lauderdale.
Owen	Bibb	Knox Dolomite.
Pace	Talladega	Knox Dolomite.
Parish	Franklin	Lafayette.
Parker	Talladega	Knox Dolomite.
Parson's Mountain	Jefferson	Carboniferous.
Patterson	Talladega	Knox Dolomite.
Pendley	Talladega	Knox Dolomite.
Pentegrass	Calhoun	Montevallo.
Phillips	Talladega	Knox Dolomite.
Phillips' Mill	Talladega	Knox Dolomite.
Pine Grove Church	Talladega	Knox Dolomite.
Plear Place	Calhoun	Knox Dolomite.
Player	Talladega	Weisner.
Poorhouse	Talladega	Weisner. Knox Dolomite.
Pruett	Calhoun	Weisner, Montevallo.
Pryor Childress Hill	Cherokee	Weisner.
Ragan	Talladega	Knox Dolomite.
Reynolds, O. M.	Talladega	Weisner. Knox Dolomite.
Reynold & Whiting	Talladega	Knox Dolomite.
Ridgeway	Marshall	Carboniferous.
Riggins & Averett	Talladega	Knox Dolomite.
Riser	Talladega	Weisner.
Riser & Mallory	Talladega	Knox Dolomite.
Riser, Welch & Flournoy	Talladega	Knox Dolomite.
Rock Run Furnace	Calhoun	Knox Dolomite.
Rockwood	Franklin	Carboniferous. Lafayette.
Rocky Hollow	Calhoun	Weisner.
Rumsey	Cherokee	Knox Dolomite.
Russell	Talladega	Knox Dolomite.
Russellville	Franklin	Lafayette.
Scarborough	Calhoun	Montevallo. Weisner.
Seay	Talladega	Knox Dolomite.
Seddon	St. Clair	Knox Dolomite.
Shelby	Shelby	Montevallo. Overlies
Shelton	Calhoun	Knox Dolomite.
Sherrill	Talladega	Knox Dolomite.
Shocco Springs	Talladega	Knox Dolomite.
Shultz Creek	Bibb	Tuscaloosa, Lafayette
Singleton	Talladega	Knox Dolomite and Montevallo.
Skinner	Calhoun	Montevallo Weisner.

Alphabetical List of Brown Ore Deposits.—Continued.

NAME	COUNTY	GEOLOGICAL FORMATION
Smith, E. R.	Talladega	Knox Dolomite.
Sprague	Calhoun	Knox Dolomite.
Stockdale	Talladega	Knox Dolomite.
Stone Place	Talladega	Knox Dolomite.
Stonewall (Langdon) Furnace	Cherokee	Weisner.
Sulphur Mountain	Talladega	Knox Dolomite.
Talladega I. & S. Co.	Talladega	Knox Dolomite.
Tannehill	Tuscaloosa	Tuscaloosa, Knox Dolomite, Lafayette.
Taylor	Talladega	Knox Dolomite.
Tecumseh Furnace	Cherokee	Knox Dolomite.
Terry	Talladega	Knox Dolomite.
Thomas	Talladega	Knox Dolomite.
Thompson	Calhoun	Montevallo, Weisner.
Tibbs	Cleburne	Knox Dolomite.
Tram	Cherokee	Weisner.
Truss' Mill	Talladega	Knox Dolomite.
Ursery	Calhoun	Knox Dolomite.
Walker	Calhoun	Knox Dolomite.
Washer	Calhoun	Montevallo, Weisner.
Washer	Cherokee	Knox Dolomite.
Washer	Talladega	Knox Dolomite.
Webb	Talladega	Knox Dolomite.
Weems	Cherokee	Knox Dolomite.
Weisinger	Talladega	Knox Dolomite.
Weisinger, Hendrick & Bisop	Talladega	Knox Dolomite.
Welch	Talladega	Knox Dolomite.
Whiting	Talladega	Knox Dolomite.
Whiting & Reynolds	Talladega	Knox Dolomite.
Williams	Calhoun	Montevallo.
Willman	Talladega	Knox Dolomite.
Williamson	Tuscaloosa	Tuscaloosa, Lafayette. Knox Dolomite. Overlies Coosa.
Windom	Calhoun	Knox Dolomite.
Wingo	Colbert	Lafayette.
Wirt Hill	Cherokee	Weisner.
Woodstock	Calhoun	Weisner, Montevallo.
Woodstock Iron Furnaces obtained ore from Rocky Hollow	Calhoun	Weisner.
Youtree	Franklin	Lafayette.
Zuber	Talladega	Knox Dolomite.

It is interesting to note that the deposits on Cedar Creek, Franklin county, were used as a source of ore by the first furnace built in Alabama, 1818.

The Knox Dolomite (Lower Silurian) will probably afford the greater. proportion of the brown ore that will be used in this State, although the deposits in the Lafayette (Tertiary), and in the Tuscaloosa (Cretaceous) may be depended on for many years to come.

The Cambrian deposits (Weisner, Montevallo, Coosa) are large and excellent ore is obtained from them. The Fort Payne Chert (Lower Sub-carboniferous) affords some good ore, as also the Upper Sub-carboniferous.

The most extensive brown ore workings now to be seen in the State are near Shelby, Shelby county, which are in Montevallo strata and the overlying Knox Dolomite. These deposits have been worked almost continuously for forty-five years.

The Baker Hill deposit near Tecumseh, Cherokee county, in the Knox Dolomite, is very large, as much as 140 feet of ore being exposed at one time. The deposits around Russellville, Franklin county, in the Lafayette, are also extensive and yield much ore.

In the northern part of Chilton county, 10 miles south of Shelby, are some deposits of excellent ore which are now being worked by the Clear Creek Lumber Co. The surface indications are not so favorable but under cover the ore has been found in considerable quantities and of excellent quality. The famous deposits around Woodstock, Tuscaloosa county, as Greeley, Goethite, Edwards, Williamson, Eureka, etc., continue to yield good ore. The deposits around Anniston, Calhoun county, have long yielded good material and are in operation. The Morris Mining Company has opened some deposits on the Seaboard Ry. about 4 miles from Ohatchee and between this place and Anniston. This deposit is known as the Alexander.

Note.—Many analyses of brown ore from the various ore banks in Alabama have been made by the Geological Survey of Alabama and published in its Reports. These analyses are, as a rule, of specimens selected as representing as nearly as possible the average quality of the ore. The character of the ore *as charged into the furnace* is, however, better shown by averages of a great number of analyses of the washed ore as delivered, and to this end we give the following table taken

from Burchard's Report on the Ores of the Birmingham District, Bulletin No. 400, U. S. Geological Survey, Page 169.—(E. A. S.)

Analyses of Washed Brown Iron Ore, Woodstock and Champion areas, Birmingham District, Alabama.

Description of sample.	Auth (a)	Fe.	SiO_2	Al_2O_3	Mn.	P.	H_2O
Tannehill, average, Dec. 1907	(1)	45.57	12.37	4.13	----	----	----
Tannehill, average, Dec. 1908	(1)	43.31	17.75	5.02	----	----	----
Houston, average, Dec. 1907	(1)	44.63	15.92	4.69	----	----	----
Houston, average, Dec. 1908	(1)	47.47	12.90	4.45	----	----	----
Standiford, average, June 1906	(2)	46.06	14.85	3.47	0.92	0.57	2.29
Standiford, average, Dec. 1908	(2)	41.92	15.67	3.98	0.64	0.59	6.60
Standiford, high shipment, 1908	(2)	44.45	14.00	3.55	0.48	0.64	6.40
Standiford, low shipment, 1908	(2)	39.10	19.58	3.68	1.08	0.51	5.50
Martaban, average, May, 1906	(2)	42.14	19.46	5.38	0.59	0.21	2.36
Martaban, average, Dec. 1908	(2)	44.47	12.38	4.22	1.19	0.93	6.91
Martaban, high, shipment, 1908	(2)	47.31	10.26	4.41	0.26	0.53	4.49
Martaban, low shipment, 1908	(2)	42.13	17.98	5.01	0.94	0.40	6.00
East Giles, average, June, 1906	(2)	49.62	11.22	3.75	0.71	0.57	1.42
East Giles, average, Dec. 1908	(2)	45.90	11.20	4.10	.59	.46	6.20
East Giles, high shipment, 1908	(2)	48.29	9.75	3.26	.74	.32	5.50
East Giles, low shipment, 1908	(2)	43.09	15.67	4.45	.59	.49	6.45
Greeley, stock house sample	(3)	43.08	21.04	----	----	.45	12.60
Giles, working analysis, 1906	(4)	44.47	14.05	4.20	.98	.56	3.20
Giles, working analysis, 1906	(4)	40.95	19.22	4.07	----	----	.95
WoodwardI.Co.,analysis (b) 1908	(5)	49.00	14.60	4.80	----	.63	----
Champion, average, Dec. 1908	(2)	47.19	12.50	2.44	.72	.26	7.10
Champion, high shipment, 1908	(2)	52.04	5.18	2.13	.84	.24	6.05
Champion, low shipment, 1908	(2)	42.76	18.13	3.72	.60	.18	7.20

(*a*) Authorities: (4) Central Iron and Coal Company; (3) McCalley, Henry, Report on the Valley Regions of Alabama, Part II, 1897, p. 462; (1) Republic Iron and Steel Company; (2) Tennessee Coal Iron and Railroad Company; (5) Woodward Iron Company.

(*b*) Dry-screened ore.

The amount of brown ore produced in the State since the statistics of production covered this as a separate item, is given in the following Table, taken from the reports of Mr. John Birkinbine to the United States Geological Survey.

TABLE V.—*Production of Brown Ore, tons of 2240 Pounds.*

PRODUCTION.

Year	Production.
1889	379,334
1890	359,518
1891	462,047
1892	655,043
1893	461,118
1894	310,724
1895	368,403
1896	346,845
1897	360,038
1898	548,637
1899	751,561
1900	769,558
1901	731,310
1902	1,008,839
1903	905,269
1904	787,514
1905	781,561
1906	821,301
1907	895,442
1908	958,535
1909	1,144,836
1910	1,123,136
1911	835,886
Total	16,957,455

The total production of brown ore in Alabama from 1880 to 1911 inclusive is seen to be about 16,957,455 tons.

The high-water mark was reached in 1909 with 1,144,836 tons. The trade in Alabama could easily take care of two million tons a year. The addition of increasing amounts of brown ore to the furnace burdens is much to be recommended and we are likely to see a greater extension of brown ore mining during the next few years, if there are no serious disturbing elements in the general iron and steel industry.

In 1901 the production of brown ore was 731,310 tons, in 1910 it was 1,123,136 tons, or an increase of 53.6 per cent. during this period. In 1891 the production was 462,047 tons and 769,558 tons in 1900, or an increase of 66.6 per cent.

From 1891 to 1900 the increase in the production of brown ore was considerably larger than between 1901 and 1910, although the total quantity produced was much larger in the latter period. We have no statistics bearing on the exportation of brown ore from Alabama to other states nor on the im-

portation into Alabama from other States. Alabama has sent a considerable tonnage of brown ore to Tennessee and Georgia, while it has received a considerable tonnage from Georgia and Tennessee and a little from Texas. The best brown ore that has been used in Alabama has come from Texas, shipments of more than 2000 tons having shown an average of more than 57 per cent. of iron, with phosphorus less than 0.20 per cent. But this business has entirely ceased, as the freight rate was $2.20 a ton from east Texas points to points in the Birmingham district.

MILL CINDER.

Another material used in the Birmingham district as a source of iron is mill cinder. It is a product from the rolling mills. The composition varies somewhat, as follows:

	Per cent. of iron
Equal parts of heating furnace and puddle cinder	56.59
Equal parts of cinder made with coal, with gas and puddle cinder	51.33
Equal parts of flue and tap cinder	50.08

The average composition of ordinary mill cinder is as follows:

	Per cent.
Metallic iron	50.00
Silica	20.00
Alumina	1.50
Lime	0.50
Sulphur	1.50
Phosphorus	0.60

It is not used regularly, but in broken doses, so to speak, as a "scouring" material.

Nearly all of the ore used in the rolling mills as "fix" comes from the Lake Superior mines.

BLUE BILLY, OR PURPLE ORE.

This is the waste material from sulphuric acid works. When pyrite is roasted, with free access of air, the sulphur it con-

tains is driven off as sulphur dioxide and this is used to make sulphuric acid. The residue is oxide of iron, with silica, alumina, etc. It contains variable amounts of sulphur, depending on the perfection of the roast. Improperly roasted pyrite may contain as much as 3.50 per cent. of sulphur. Some of the pyrite used in the manufacture of sulphuric acid in the fertilizer establishments in Alabama, Mississippi, Tennessee, Georgia, etc., is now obtained from domestic sources (Georgia, Alabama, etc.,) but a good portion of Spanish pyrite is also used. Nearly all of this material, whether of domestic or foreign origin, contains a little copper, up to 2.50 per cent., and this is now extracted by one establishment in Montgomery. By roasting the blue billy with common salt and extracting the mass with dilute hydrochloric acid the copper is removed and is recovered, as cement copper, by allowing the solution to remain in contact with metallic iron such as old castings, scrap, etc. By this or a similar process the sulphur also may be almost entirely removed and the material made more suitable for "fix" in the rolling mills.

"Blue billy" may also be nodularized and used in blast furnaces in this condition.

An analysis of the "blue billy" used in the Birmingham district is as follows:

	Per cent.
Metallic iron	56.07
Insoluble	14.03
Sulphur	2.59
Phosphorus	0.032

In exceptional cases the metallic iron may go to 60 per cent.

FLUE DUST.

The flue dust from the down-comers, attached to the blast furnaces, might be used as a source of iron. Some investigations made several years ago by the writer showed that two furnaces of a capacity of 250 tons of iron per day made 10 tons of flue dust in 24 hours. The composition of flue dust was discussed by the writer in the Proc. Ala. Indust. & Sci. Soc., Vol. IV, No 2, 1894. The content in iron was found to

be 43.00 per cent. and of insoluble matter 16.70 per cent. It is magnetic but can not be much improved by concentration. It is a very fine material, as the following investigations will show:

Fineness and Composition of magnetic portion of Flue Dust.

Left on		Per cent.	Iron Per cent.	Insoluble. Per cent.
10-mesh	screen	0.06	51.93	15.00
20 "	"	0.53	38.42	19.95
30 "	"	5.34	43.38	17.30
40 "		6.62	39.46	21.70
50 "	"	10.30	41.54	18.96
60 "	"	9.00	40.38	17.96
70 "	"	10.00	41.67	14.68
80 "	"	35.00	44.00	14.00
90 "	"	10.00	45.00	13.50
Through 100 "	"	10.00	44.50	14.00

The percentage of iron in the magnetic portion of flue dust varies from 40.38 in the material passing a 50 and remaining on a 60-mesh screen, after removing the coarser stuff, to 51.93 in the material remaining on a 60-mesh screen.

The magnetic portion comprises from 75 to 85 per cent. of the flue dust. The non-magnetic portion carries from 1.87 per cent. to 9.10 per cent. of iron, from 2.20 to 7 per cent. of volatile matter and from 41 to 76 per cent. of fixed carbon, according to the degree of fineness. The metallic iron present (shown by the evolution of a hydrocarbon on treating the dust with acid) may be due to the iron mechanically removed from the bell and hopper during charging, to reduce iron in a finely divided condition, or to both these causes. The volatile matter comes from the coke, stone and ore of the burden and the fixed carbon comes from the coke.

The average amount of metallic iron in the dust is about thtat of the ore charged. The material is so fine that the only feasible way of utilizing it is to briquet it or sinter it.

Analysis of the non-magnetic portion of the dust was as follows:

Left on	Pct. of Total	Vol. matter Pct.	Fixed carbon Pct.	Iron oxide Pct.	Alumina Pct.	Lime Pct.	Silica Pct.	Ash Pct.
10-mesh	0.73	3.30	70.95	6.58	4.72	2.60	7.40	25.75
20 "	3.42	2.20	76.30	4.12	2.68	1.50	6.40	21.50
30 "	8.66	3.80	71.40	3.70	2.50	1.60	9.35	24.80
40 "	4.49	2.80	61.80	2.68	4.14	5.50	15.15	35.40
50 "	4.40	6.10	52.70	4.44	4.06	8.40	20.20	41.20
60 "	3.30	6.15	53.95	3.75	4.00	9.00	17.20	39.90
70 "	3.00	6.70	47.85	12.26	3.00	8.50	17.30	45.45
80 "	5.00	7.00	45.50	11.50	3.75	10.00	18.50	47.50
100 "	4.00	6.00	42.00	13.00	4.00	9.00	20.00	52.00
Through 100 "	2.00	5.00	41.00	12.00	5.00	8.00	22.00	54.00

It has already been stated that from two furnaces of 250 tons capacity, each, 10 tons of dust were obtained in 24 hours, or five tons from each. It is obvious that the amount to be obtained varies with several conditions, such as the character of materials charged into the furnace, method of charging, pressure of the blast, etc. No general rule governing the amount produced per furnace per 24 hours can be given. Flue dust is, however, a material which should be saved. Perhaps the best plan would be to sinter it and return it to the furnace, using the furnace gases as fuel.

CHAPTER IV.

CONCENTRATION OF ORES.

Excluding the gray (hematite) ores, of the Sylacauga district, which have not been experimented with on a large scale, there are two classes of ore which have been concentrated on a working scale. These are the low grade red hematites, including both the soft and the hard, and the low grade brown ores.

RED HEMATITE.

Two methods have been used in concentrating this class of ore. The first was based on artificial magnetization and subsequent separation of the silica from the oxide of iron over a magnetic machine. But it was soon found that it was not necessary to render the ore magnetic by artificial means and further experiments in this direction were discontinued. The results were extremely interesting and were communicated by the writer to the American Institute of Mining Engineers, Atlanta Meeting, October, 1895. The subject has not been pursued since that time.

Many experiments on a working scale were made with the Wetherill and with the Payne machine. Various working tests were made on a variety of material and some 500 analyses were carried on during the experiments. The data gathered between the years 1895 and 1897 have not been added to since. No plants have been established and there is no further information than was given in the second edition of this book, 1898.

Of late, however, there has been a revival of interest in this matter and it has been thought best to publish anew the results of that early work.

In concentrating the low grade red hematites we have to do with a material consisting of small siliceous pebbles held together in a cement of oxide of iron containing also some silica and alumina.

These pebbles vary in size from that of a buck-shot (¼ inch) to that of a mustard seed (1-32 to 1-64 inch.) They are an essential part of the ore, but may, to some extent, be separated from the oxide of iron by mechanical means, crushing and screening. Thus it was found that on crushing a low grade soft ore, with 37 per cent. of iron, through a 15-mesh screen, 33 per cent. of it would pass a 40-mesh screen and carry from 49 to 54 per cent. of iron. This means that the cementing material, rich in iron, is much softer than the ore itself and may be separated from the ore by crushing and screening.

The better grade of ore does not need to be concentrated, but some experiments were made with an ore carrying 48 per cent. of iron with the following results:

	Metallic iron Per cent.	Insol. Matter Per cent.
Original ore with	48.03	25.20
Gave		
57 per cent. of heads with	57.10	13.10
28 per cent. of middlings with	46.20	25.40
15 per cent. of tails with	10.00	70.80

It was also found that about 20 per cent. of this ore could be brought up to 59.15 per cent of iron and 10.45 per cent of insoluble matter.

It is obvious that a soft ore carrying 48 per cent of iron does not need to be concentrated. By direct concentration, i. e., sending the ore to the machines without previously magnetizing it, there is a larger proportionate gain in the percentage of iron when the lower grade ores are used than when the higher grade ores are used. For example:

	Metallic iron Per cent.	Insol. Matter Per cent.
Original ore with	41.58	37.51
Gave		
69 per cent. of heads with	52.00	23.00
31 per cent of tails with	18.40	70.00

About 25 per cent. of this ore was raised to iron 56.40 per cent.. insoluble matter 17.00 per cent.

Mr. H. A. J. Wilkens and Mr. H. B. C. Nitze, representing the Wetherill Separating Company, were associated with the writer in the conduct of these tests, the means having been provided by the Tennessee Coal, Iron & Ry. Company. The plant was at the Little Belle Furnace, Bessemer.

What has preceded and what follows has been taken from a paper read by Messrs. Wilkens & Nitze at the Pittsburg meeting of the American Institute of Mining Engineers, February, 1896; from a series of articles communicated to the Engineering & Mining Journal, N. Y., by the writer, Vol. LXII, pp. 75, 105, 124 and 151 and from his own note books.

The Wetherill Inclined Magnet machine and the Flat Magnet machine were used, sometimes the one and sometimes the other. The soft red ore was crushed through a 15-mesh screen and fed to the machine running at 8 amperes and 100 volts.

	Iron Per cent.	Insol. Matter. Per cent.
Original ore with	39.20	40.16
Gave		
52.4 per cent. of heads with	56.40	17.10
6.9 per cent. of middlings with	38.85	41.35
40.7 per cent. of tails with	16.70	74.10

The gain of the heads in iron was 43.8 per cent. over the original ore, and the decrease in the insoluble matter was 57.4 per cent. To make one ton of concentrates carrying 56.40 per cent. of iron there was required 1.91 tons of raw ore. In other words, from 1.91 tons of ore carrying 39.20 per cent of iron and 40.16 per cent. of insoluble matter there was obtained one ton of ore with 56.40 per cent. of iron and 17.10 per cent. of insoluble matter. This result was not secured at one operation, the course of treatment being as follows: First pass, 10 amperes, 100 volts.

	Iron Per cent.	Insoluble. Per cent.
Original ore with	39.20	40.16
Gave		
59.3 per cent. of heads and middlings with	54.10	18.80
40.7 per cent. tails with	16.70	74.10

The heads and middlings from the first pass were re-passed at 8 amperes and 100 volts, and two products were obtained:

	Iron Per cent.	Insoluble. Per cent.
Middlings, 4 per cent. with	31.40	52.20
Heads and middlings, 55 per cent. with	54.10	18.70

These second heads and middlings were re-passed at 6 amperes and 100 volts, and two products were obtained:

	Iron Per cent.	Insoluble. Per cent.
Middlings, 2.9 per cent. with	46.30	30.50
Heads, final, 52.4 per cent. with	56.40	17.10

We could have stopped with the first heads and middlings and have obtained 59.3 per cent. of the original ore with 54.10 per cent. of iron and 18.80 per cent. of insoluble matter. We may say, then, that from a soft red ore carrying 39.20 per cent. of iron and 40.16 per cent of insoluble matter we obtained at the first pass 59.3 per cent. of concentrates with 54.10 per cent. of iron and 18.80 per cent of insoluble matter. The gain in the percentage of iron was 38 per cent. above the original ore and the decrease in siliceous matter was 53 per cent. One hundred tons of this ore would yield 59.3 tons of concentrates with 54.10 per cent. of iron and 40.7 tons of tails with 16.70 per cent. of iron.

In some of our operations the amount of raw ore passing a 40-mesh screen after crushing through a 15-mesh, was 33 per cent. and this contained 49.4 per cent. of iron and 26.50 per cent. of insoluble matter. The fines from this low grade ore were much richer in iron than the coarse material. They carried from 49 to 54 per cent. of iron even when the original ore had only 37 per cent. The more ferruginous portion of the ore is softer than the more sandy portions and it is possible to effect a considerable concentration merely by crushing the dry ore and passing it over a 40-mesh screen. The amount of material passing through a 40-mesh screen, after passing a 15-mesh, varies from 25 to 35 per cent. of the weight of the ore, so that we may expect to get up to 54 per cent. of iron in

one-fourth to one-third of the ore simply by crushing and screening. There is an increase of iron in the material passing a screen finer than 40-mesh, but not enough to be of much importance. Over the Inclined Magnet Machine (Wetherill Process) this fine material can be concentrated somewhat, as the following results show:

	Iron Per cent.	Insoluble. Per cent.
Fines, through 40-mesh screen with	49.40	26.50
At 10 amperes and 100 volts gave:		
12.6 per cent. of heads with	55.30	17.12
22.8 per cent. of middlings with	51.75	21.10
64.6 per cent. of tails with	45.80	30.35

The gain of the heads in iron was 11.9 per cent. and the decrease of insoluble matter was 35.4 per cent.

Numerous experiments with this material satisfied us that it would not be profitable to attempt its concentration. It should be briquetted at once or mixed with "heads" and briquetted. It makes a good paint and might be used for this purpose.

In order to determine the possibility of using coarser material, i. e., to avoid so fine a crushing as through a 15-mesh screen, we conducted a number of experiments on material that had passed an 8-mesh screen but was retained by a 15-mesh.

Material through an 8-mesh screen, but retained by a 15-mesh. Incline Magnet Machine (Wetherill.)

	Iron Per cent.	Insoluble. Per cent.
Original ore with	35.40	46.34
At 6 amperes and 100 volts gave:		
45.5 per cent. of heads with	50.20	24.34
19.0 per cent of middlings with	43.00	34.95
55.5 per cent. of tails with	15.40	75.35

By re-passing the middlings the yield of heads could be increased to 50 per cent. and they would probably carry 50 per cent. of iron. But it did not appear that it would be profitable to use ore of this degree of coarseness, as the mechanical separation of the material into a ferruginous portion and a more siliceous portion is better when the material is passed

through a 15 or 20-mesh screen. Crushing the ore merely separates it into two distinct portions, the one carrying excess of iron, so to speak, and the other carrying excess of silica. The machine merely divides the one from the other, but there must be a degree of fineness better adapted for this separation than any other degree. This depends largely upon the nature of the ore itself. For the low grade soft red ores it appears to lie somewhere between a 10 and a 20-mesh. We found that a 15-mesh gave the best results.

The following results are taken from the writer's notebooks. The Wetherill machines were run under 8 amperes and 100 volts.

	Iron Per cent.	Insoluble. Per cent.
Original soft red ore with	34.90	47.12
Gave:		
52 per cent. of heads with	49.20	25.84
20 per cent. of middlings with	39.20	41.00
28 per cent of tails with	14.00	78.14

The middlings should be re-passed at a lower amperage.

	Iron Per cent.	Insoluble. Per cent.
Original ore with	36.80	45.56
Gave:		
46 per cent. of heads with	52.90	21.24
15 per cent. of middlings with	37.45	43.62
39 per cent. of tails with	17.20	74.68
Original ore with	39.20	40.16
Gave:		
51.6 per cent. of heads with	52.50	22.60
11.4 per cent. of middlings with	32.05	51.89
37.0 per cent. of tails with	16.10	74.76

This ore was tried again under somewhat different conditions with the following results:

Original ore with	39.20	40.16
Gave:		
56.4 per cent. of heads with	53.80	19.02
43.6 per cent. of tails with	24.70	62.20

The conditions were again changed with the following results:

Original ore with	39.20	40.16
Gave:		
52.4 per cent. of heads with	56.40	17.10
6.9 per cent. of middlings with	38.85	41.35
40.7 per cent. of tails with	16.70	74.10

These last results have been already quoted.

	Iron Per cent.	Insoluble. Per cent.
Original ore with	34.82	47.60
Gave:		
42 per cent. of heads with	55.60	17.00
18 per cent. of middlings with	37.95	43.17
40 per cent. of tails with	13.50	79.88
Original ore with	42.00	36.42
Gave:		
59.0 per cent. of heads with	51.00	25.20
23.7 per cent. of middlings with	45.70	31.76
17.3 per cent. of tails with	12.90	79.80
Original ore with	37.30	42.90
Gave:		
47 per cent. of heads with	53.25	19.05
24 per cent. of middlings with	30.26	51.94
29 per cent. of tails with	13.70	78.70
Original ore with	37.36	42.73
Gave:		
46 per cent. of heads with	50.50	22.12
15 per cent. of middlings with	36.80	42.73
39 per cent. of tails with	15.80	74.20

The results of many more experiments might be given, but these are sufficient to show the possibilities of utilizing the low grade soft red ores. The experiments were conducted on a large scale. The machines were of full working size and the amount of ore treated was in excess of 500 tons. The work extended over several months and many varieties of ore were used.

What was ascertained by these tests? In answering this question we will refer to the work on the lowest grade ore that was used. It contained 34.82 per cent. of iron and 47.60

per cent. of insoluble matter (silica, for all practical purposes) This ore can not be used for making iron. Unless it can be concentrated it is worthless. By crushing this ore and passing it through a 15-mesh screen we found that 100 tons yielded, over the Wetherill Machine:

	Iron Per cent.	Insoluble. Per cent.
42 tons of heads with	55.60	17.00
18 tons of middlings with	37.95	43.17
40 tons of tails with	13.50	79.88

By re-passing the middlings a larger proportion of heads could have been secured but the content of iron would have been less.

If an ore contains 34.82 per cent. of iron we would have to use of it 3195 pounds to obtain as much iron as would be yielded by 2000 pounds of an ore with 55.60 per cent. of iron. In order to get 2000 pounds of 55.60 per cent. ore we would have to use 4,760 pounds of the raw ore, because we save only 42 per cent. by weight, as heads. In other words, from 4760 pounds of raw ore, carrying 34.82 per cent. of iron, we get 2000 pounds of heads with 55.60 per cent. of iron, 856 pounds of middlings with 37.95 per cent. of iron and 1904 pounds of tails with 13.50 per cent. of iron.

By mixing the heads and middlings we would get 2856 pounds of material with 50.37 per cent. of iron and discard 1904 pounds of tails, with 13.50 per cent. of iron. In the 4760 pounds of raw ore we have 1657 pounds of iron, of which we recover (in heads plus middlings) 1438 pounds (86.7%) and lose 218 pounds (13.3%) in the tails. This is certainly a most interesting result.

Take another case. The raw ore contained 36.80 per cent. of iron. Of this there would be required 2875 pounds to contain as much iron as 2000 pounds of the heads carrying 52.90 per cent. of iron. In order to get the 2000 pounds of heads, with 52.90 per cent of iron, we would have to use 4348 pounds of the raw ore, because we have only 46 per cent. by weight, as heads. In other words, from 4348 pounds of raw ore we would get 2000 pounds of heads, with 52.90 per cent. of iron, 652 pounds of middlings with 37.45 per cent. of iron and 1695 pounds of tails with 17.20 per cent. of iron. By mixing the

heads and middlings we would get 2652 pounds of material with 49.10 per cent. of iron and discard 1695 pounds of tails with 17.20 per cent. of iron. In the 4380 pounds of raw ore we have 1600 pounds of iron, of which we recover (in heads plus middlings) 1302 pounds (81.4 per cent.) and lose 298 pounds (18.6 per cent.) in the tails.

These tests were not made in the laboratory on a few pounds of material, they were made on car-load lots of ore and extended over several months. Conditions as to fineness of material treated, speed of the machines, amperage and voltage used and character of the raw ore were such as to give a wide range of observation. The conclusions reached were that it was entirely feasible to make concentrates of 50 per cent. of iron and above from ores that were worthless for the blast furnace and the yield of such concentrates would be not less than 50 per cent., by weight, of the raw ore. The extraction of the available iron in the raw ore was about 85 per cent. In some important instances the yield of workable concentrates was 60 per cent. of the raw ore treated, an ore otherwise worthless.

When one considers that during the five years ending with 1905 the average yield of all the ores used in this State was 44.4 per cent. of iron, a calculation based on the consumption of more than 17 million tons. and that the average yield of the soft red ore is not so great as this. a system by which the iron-content in the soft red ore is increased to more than 50 per cent. would appear to be worth the closest attention. Not only is the content of iron largely increased, there is also a large decrease in the content of silica, so that the cost of using this ore is much less than the cost of using the more siliceous ores.

There is an enormous quantity of low grade soft red ore within a few miles of Birmingham which can not be utilized unless it is concentrated. At many localities the stripping has already been done and the upper and better portion of the seam removed, so that the ore now remaining can be obtained at a very low cost.

It is probable that the best results from the use of concentrates wouud be secured by briquetting them, although a not inconsiderable proportion of the Mesabe ore will pass a screen of 15-mesh. There is no longer much difficulty in using as much as 60 per cent. of fine material.

There is no question at all of the supply of the low grade soft ore in the Birmingham district, the amount available running into millions of tons.

The cost of the operation has not been fully determined, because there has been no commercial plant erected for the purpose. The tests that were made, while on a full working scale, were designed more to prove the feasibility of the process, from a concentration stand-point, than from a commercial staind-point. The cost of producing a ton of 50 per cent. concentrates now, under favorable conditions, would probably be about $1.35 and this kind of ore is now worth from $1.60 to $1.80 a ton. For 55 per cent. concentrates, briquetted, the price would be $2.00 a ton. There is an open field here for the further prosecution of this work, a ready market for the ore and a very large supply of raw material.

Hard (Limy) Red Ore.—There will be given first the results of two tests on the ordinary hard ore.

	Iron Per cent.	Lime Per cent.	Insoluble. Per cent.
Original ore with	37.60	15.00	16.20
Gave:			
55 per cent. of heads with	48.70	9.76	10.26
15 per cent of middlings	29.00	21.40	18.20
30 per cent. of tails with	18.20	25.12	27.00
Original ore	34.50	17.10	18.04
Gave:			
64 per cent. of heads with	45.40	11.45	12.25
7 per cent. of middlings	25.80	24.02	17.95
29 per cent. of tails with	13.55	27.10	30.34

To bring the iron up from 37.60 per cent. to 48.70 per cent. in the heads and at the same time preserve the self-fluxing character of the ore is very encouraging. The results from the second test are still better.

Other hard ores were tested, as follows:

	Iron Per cent.	Lime Per cent.	Insoluble. Per cent.
Original ore	31.80	10.79	33.10
Gave:			
44 per cent. of heads with	43.15	8.80	19.66
6 per cent. of middlings with	29.45	12.40	32.90
50 per cent of tails with	22.80	12.52	43.82

	Iron Per cent.	Lime Per cent.	Insoluble. Per cent.
Original ore	32.80	9.90	33.70
Gave:			
58 per cent. of heads with	44.50	9.00	17.30
10 per cent. of middlings with	35.90	13.20	23.28
32 per cent. of tails with	21.60	8.80	42.70

In the original condition these ores are not self-fluxing, nor do they become so by concentration, but they are greatly improved.

In the one case the ratio in the raw ore between the lime and the siliceous matter is 1:3, but in the heads it was reduced to 1:2.2. In the other case the ratio was 1:3.4 and it was reduced to 1:1.9 in the heads.

There does not seem to be the same necessity for concentrating the hard ore as maintains with the low grade soft ore and these tests were conducted more for the purpose of studying the hard ore over the machines than for any other.

Brown Ore.

Some experiments on concentrating brown ores were made with the Wetherill Machine, but the results were not of commercial importance. We found that an ore carrying, on dry basis, 45 per cent. of iron and 18 per cent. of silica could be improved so that about 55 per cent. of it carried 52 per cent. of iron. In the paper already referred to Messrs. Wilkens and Nitze gave results from concentrating certain brown ores. Thus an ore from Iron Gate, Alleghany county, Virginia, gave the following:

	Iron Per cent.	Silica. Per cent.
Original ore	43.08	31.29
Gave:		
63.4 per cent. of concentrates	51.04	11.24
36.6 per cent. of tails with	31.74	----

Washer-tailings from Barren Springs, Virginia, gave:

Original ore	32.03	29.93
Gave:		
30 per cent. of concentrates	53.14	7.43
70 per cent. of tails with	22.98	39.58

It may be that some such process will be found applicable to low grade brown ores, especially to washer-tailings and kiln-screenings, but the outlook at this present time is not particularly encouraging. There are doubtless many brown ores whose initial content of iron is so low as to forbid the use of the calcination process and some magnetic process may eventually be applied to them. Calcining is not commonly practised in Alabama. Some of the charcoal furnaces formerly calcined their ores, but the practice is dying out. Only a small proportion of the brown ore mined and used in the State is subjected to any other treatment than washing.

When calcining was practised one of two methods was used, the old fashioned open air pile fired with charcoal breeze, etc., and the modern gas-fired kiln. The former method needs no description. When carefully managed it gives fair results, but can not be depended on to yield uniformly calcined ore. Even with proper attention, which it seldom received, a part of the ore was not calcined at all, a part was well calcined and a part was "louped."

The Davis-Colby gas fired kiln has given the best results. In this kiln the current of heated gas and flame is drawn across the ore as it descends between the outer walls of the combustion chamber and a central space connected with the stack. The kiln is built in any size, from 100 to 150 tons, and is fired with producer-gas.

Allowing 7 per cent. of ordinary moisture, removable at 212 degrees F., and 7 per cent. of combined water removable only at red heat, a kiln holding 125 to 140 tons of raw ore will deliver from 107 to 120 tons of thoroughly and uniformly calcined ore per 24 hours, with a consumption of 2½ to 3 tons of coal. To calcine one ton of raw ore requires about 52 pounds of coal. A kiln would cost now about $9,000.

The freight on a ton of raw ore from the washer to the furnace may be taken at 25 cents and if the ore averages 47 per cent. of iron we would have a freight charge of 25 cents for 1052.8 pounds of iron. The freight on a ton of calcined ore would also be 25 cents, but in this case we would have 1209.6 pounds of iron as against 1052.8. Each ton of ore delivered at the furnace would contain 156.8 pounds of iron more than the raw ore. In other words, 121.7 tons of calcined ore contain as much iron as 140 tons of raw ore and the saving

of labor at the furnace would be one man a day, reckoning that four men are required to handle the 140 tons and three men for the 121.7 tons.

If the kilns should be at the furnace, so that the bottom-fillers could draw the ore direct from the kiln-shutes, the economy would be greater. At one well managed plant this has been the custom for some years. The ore trams come in from the washer and discharge into the kilns. The bottom-fillers draw from the shutes into the furnace buggies and the hot ore goes direct to the top.

The life of a brown ore deposit is so uncertain that it might be best to consider the erection of the kilns at the furnace. The furnace operators could purchase ore from the smaller ore companies, which can not undertake the expense of building and operating the kilns. Allowing that a raw brown ore will lose 14 per cent. by calcining we would have the following increases in the content of metallic iron:

An ore of 42 per cent. would have	48.84 per cent.
An ore of 44 per cent. would have	51.16 per cent.
An ore of 46 per cent. would have	53.48 per cent.

In addition to the increase in iron calcined brown ore has also the marked advantage of being more porous than the raw ore and on this account more easily reduced in the blast furnace.

In this State we may be approaching the time when much closer attention will have to be given to preparing brown ores for market. The necessity for considering this matter lies not so much in the direction of calcining in kilns as in that of properly cleaning the ore from clay and chert. Under suitable and not expensive conditions the clay may be removed by washing, but the chert will have to be removed by crushing, hand-picking and jigging. There are not many deposits of brown ore that contain the ore in such condition that it may all be prepared for market by washing and screening. Such deposits are comparatively rare. Most of the deposits contain the ore in two forms, as more or less gravelly material mixed with clay, which can be removed in water, and as intimate mixtures of ore and chert (siliceous matter). It often happens that much good ore is lost because it is so intimately commingled

with the chert as to require crushing and jigging for its separation. It is not a difficult matter to wash brown ore free of its adhering clay and the operation does not call for an expensive installation. By far the greater part of the brown ore mined in this State is obtained from the clays. When such deposits show signs of exhaustion it will become necessary to secure the ore which is held in the chert and this will demand a different method of treatment. Crushing, sizing and jigging machinery will then have to be used and this may not be so far distant as some may suppose.

Whether or no such processes are to be recommended at the present time, or within the immediate future, depends largely upon local circumstances and the price of ore but that such a change in the preparation of brown ore will eventually be required does not seem to admit of much doubt. It is impossible to say how much of the brown ore now supposed to be in reserve exists in "banks" from which the clay may be removed by washing and how much exists in more or less intimate association with chert. But it is true that the cherty ores are more in evidence than the others.

As to the comparative amount of phosphorus in the loose ore and the cherty ore we have no sufficient data on which to base an assertion. The irregularity of the distribution of the phosphorus in brown ore deposits is one of the perplexing things in such mining.

CHAPTER V.

THE FLUXES.

The material used for flux is either limestone, dolomite, or a mixture of the two, the tendency now being towards the use of dolomite. When the stone is sold on analysis, which is the prevailing custom, the sliding scale is used. As a rule the limestones carry much more silica then the dolomites. If the basis of sale is 3.50 per cent. of silica two-tenths of a cent per ton is taken off for each quarter of one per cent. above 3.50 and the same amount is added to the price for each quarter of one per cent. below 3.50. Thus if the delivery price is 60 cents a ton for a 3.50 per cent. stone and the silica should run to 3.75 the price would be 59.8 cents per ton. If the silica should fall to 3.25 per cent the price, per ton, would be 60.2 cents.

The average analysis of the limestone used is as follows:

	Per cent.
Silica	3.50
Oxide of iron and alumina	1.00
Carbonate of lime (equivalent to)	94.60
Caustic lime (lime)	53.00

The silica is sometimes higher than 3.50 per cent., but the above analysis represents the average composition of a good quality of stone. Large shipments of stone from the Bangor quarries, on the other hand, have held less than 0.60 per cent. of silica.

During the last years the use of dolomite (carbonate of lime and magnesia) has largely increased, following the increased production of basic iron. Plates XIII and XIV.

In the manufacture of basic iron it was soon found that the use of dolomite was a decided advantage, especially in the lowering of the sulphur in the pig iron. Whether this advantage was due to the lower content in silica, 1.25 as against 3.50, or whether the presence of large quantities of magnesia was

DOLOMITE QUARRY AT DOLCITO, JEFFERSON COUNTY.
TENNESSEE COAL, IRON AND RAILROAD CO.

DOLOMITE QUARRY AT THOMAS, JEFFERSON COUNTY, SHOWING PROXIMITY OF FURNACES, TO WHICH THE STONE IS DELIVERED BY COMPANY'S RAILROAD. REPUBLIC IRON AND STEEL COMPANY.

the determining factor, in diminishing the sulphur content in the iron, is a question which still occasions mild disputes. The fact remains, however, that in the production of basic iron, sold under severe restrictions as to silicon and sulphur, only dolomite is used as flux.

Aside from its low silica content, the dolomite possesses the advantage of greater uniformity in composition. This is much in its favor. The writer's experience covers many thousand cars of both limestone and dolomite and it has been observed that while the limestone is subject to considerable variation in silica content the dolomite is of remarkable uniformity. The highest amount of silica found in lump dolomite is a trifle over 1.50 per cent., the ordinary range being from 0.75 to 1.25.

The average composition of the dolomite is as follows:

	Per cent.
Silica	1.25
Oxide of iron and alumina	1.00
Carbonate of lime (Lime 30.31)	54.00
Carbonate of magnesia (Magnesia 20.71.)	43.00

The ratio between the magnesia and the lime does not vary much from 1:1.50.

Both the limestone and the dolomite carry small amounts of sulphur, the maximum so far observed being 0.11 per cent.

As in the limestone quarries there are layers of siliceous material, so in the dolomite quarries there are ledges of almost pure silica, white as porcelain. They seem to be flinty concretions, occurring in more or less regular bands, from one-half inch to three inches in thickness. It is customary to separate these flinty nodules from the stone by hand, before shipping.

The more impure limestone is of darker color than the good stone, but the more impure dolomite is much lighter in color than the better grades. There is a kind of dolomite occurring in some of the quarries that is deceptive to the eye. It looks not unlike coarse brown sugar, has the same damp appearance and glistens in the sun light. To the hand it feels sandy, but on analysis it is found, for the most part, to be the best stone in the quarry, some samples showing only 0.25 per cent. of silica. Not all of this loose, sandy looking dolomite, how-

ever, is low in silica, some of it carries 3.00 per cent. and one sample carried 4.00 per cent. It does not form a large proportion of the material in the quarry and is mined and shipped with the other stone. Both limestone and dolomite are quarried on the face, no underground work being required. Crushed or lump stone is shipped as the demand may require.

The amount of stone used per ton of iron varies of course, with the quality of the stone, with the nature of the ore and fuel and, to some extent, with the grade of iron made. The range is from 0.30 to 0.80 of a ton.

No attempt has been made on any considerable scale to use calcined stone, whether limestone or dolomite, except in so far as the calcination of the limy ore may be considered an attempt to calcine the carbonate of lime contained in it. The question may be stated in general terms. As already observed, th limy ore is an intimate mixture of oxide of iron, silica, alumina and carbonate of lime. The better grades contain 37 per cent. of iron, 13.30 per cent. of silica and 15.50 per cent. of lime. The admixture of these materials is far more perfect than could be attained by any artificial means. Is it more economical to use this ore, in which the flux is already so well mixed with the siliceous ingredients of the ore than to use an ore of much less content of lime and therefore requiring the addition of extraneous flux? The furnace-man has merely to decide whether he can make as cheap iron, as much iron and as good iron in the one way as in the other. These are the chief questions.

In addition, however, he has to take into consideration the fact that the supplies of ore which require extraneous flux are not so large as the supplies of self-fluxing, or partly self-fluxing, ore. He is, in a measure, compelled to make use of large proportions of limy ore. His ability to diminish, at will, the consumption of limestone, by using larger proportions of limy ore, places him in an independent position with respect to the quarry-man. If the price of stone is too high he can use more limy ore and less stone. If the price of the stone is within reach the hard ore burden may be diminished and the soft, or brown, ore burden increased.

For instance: A certain coke furnace made during one month 5,000 tons of iron with a burden composed of 50.9 per cent. of hard ore and 49.1 per cent. of soft ore. The total burden was as follows:

	Per cent.
Hard ore	27.7
Soft ore	26.7
Limestone	15.5
Coke	30.1
	100.0

The consumption, per ton of iron, was as follows:

	Tons of 2240 lbs.
Ore	2.36
Stone	0.67
Coke	1.32
	4.54

The cost, for raw materials, per ton of iron, was as follows:

Ore	$1.32
Stone	0.34
Coke	1.83
	$3.49

The consumption of coke, per pound of iron, was 1.32 pounds and practically all of the iron was of foundry grades.

Shortly before, this furnace was running on a burden composed of 33.4 per cent. of hard ore, 65.3 per cent. of saft ore and 1.3 per cent. of brown ore. The total burden was as follows:

	Per cent.
Hard ore	17.0
Soft ore	33.1
Brown ore	0.6
Limestone	16.9
Coke	32.4
	100.0

The make of iron was something over 4,600 tons, practically all of foundry grades. The consumption, per ton of iron, was as follows:

	Tons of 2240 lbs.
Ore	2.20
Stone	0.73
Coke	1.41
	4.34

The cost, per ton of iron, was, for the raw materials:

Ore	$1.26
Stone	0.43
Coke	1.83
	$3.52

The consumption of coke, per pound of iron, was 1.41 pounds.

In these two cases there was a saving of 9 cents per ton of iron by increasing the proportion of hard ore and lessening the amount of limestone added, and this saving was in stone. But the ore cost 6 cents a ton more on this burden than on the other, so that the net saving was only 3 cents per ton of iron. But on the burden containing the smaller proportion of hard ore the furnace made 358 tons of iron more than on the other burden, during the same period, the grade of the iron being practically the same for the two periods.

The amount of iron made during the two periods was very nearly 10,000 tons and while it may not be well to generalize on so small a tonnage yet it is thought that the instances given are very instructive.

We are reliably informed that the raw material cost of pig iron in 1910-1911 was about as follows:

Ore, 2.6 tons @ 0.95	$2.37
Stone, 0.5 ton @ 0.60	0.30
Coke, 1.5 tons @ 2.60	3.90
	$6.57

This would mean that the ore mixture carried 38.46 per cent. of iron and it could be made by using one-third of brown ore carrying 45 per cent. of iron and two-thirds of hard red ore carrying 35 per cent of iron. But the proportion of hard (limy) ore often rises to 80, 90 and even 100 per cent. of the ore burden, with a corresponding decrease in the amount of stone required.

CHAPTER VI.

THE FUELS.

COKE.

The fuel used in the blast furnaces in Alabama is coke and charcoal. There are no known seams of coal that could be used without coking. By far the greater amount of the coke made is in the ordinary bee-hive oven. This is the only kind of oven used here, with the exception of 240 Semet-Solvay ovens at Ensley, and 40 at Holt, 280 Koppers ovens of the T. C. I. & R. R. Co. at Corey, and 60 Koppers (with 80 more under construction) at Woodward.

Three kinds of coal are used in making coke, lump, run of mines and washed slack, and exclusive of the shorter treatment in the recovery oven, from each kind is made 48 or 72-hour coke, i. e., the coal remains in the oven 48 or 72 hours. Some 96-hour coke is also made, but only as incidental to the time of charging and drawing.

Nearly all of the bee-hive coke is 48-hour and the chief difference between this and the 72-hour is in the strength of the coke, the latter having somewhat the advantage in this respect.

The following tables give the results of some experiments undertaken to establish the compressive strain of some of the principal cokes used for blast furnace and foundry purposes.

TABLE VI.—*Bee-hive Coke made from Pratt and Blue Creek Washed Coke, yearly averages from Nos.* 3, 4 *and* 5 *Pratt Coal, covering Pratt Coal and from Johns covering Blue Creek Coal.*

Pratt.

Year	Appar. Sp. gr.	True Sp. gr.	Percent cells by vol.	Ash	Sul.	Composition of Ash. SiO_2	Al_2O_3	CaO	Fe
1909	----	----	----	7.77	1.05	----	----	----	----
1910	1.047	1.793	41.50	7.10	1.06	40.99	23.94	4.79	16.06

Blue Creek.

Year	Appar. Sp. gr.	True Sp. gr.	Percent cells by vol.	Ash	Sul.	SiO_2	Al_2O_3	CaO	Fe
1909	----	----	----	10.32	.72	----	----	----	----
1910	0.836	1.761	----	10.21	.74	42.66	29.66	3.77	13.19

TABLE VII.—*48-Hour Bee-Hive Coke From Blue Creek Washed Slack.*

	Apparent Sp. grav.	True Sp. grav.	Per cent of cells by vol.	Vol. of cells in 100 parts by weight.	Comp. strain, lbs. per square inch.	Ash.	Sulphur.	Composition of Ash. Silica.	Oxide of Iron.	Alumina.	Lime.	Magnesia.	Sulphur.
No. 1	0.806	1.723	53.20	63.34	369	10.60	0.90	40.30	23.15	33.42	1.20	0.44	0.16
No. 2	0.848	1.755	51.67	60.92	400	11.80	0.93	42.30	19.25	34.70	1.50	0.60	0.14
No. 3	0.847	1.739	51.30	60.58	375	9.15	0.85	42.55	17.71	35.94	1.82	0.54	0.14
No. 4	0.839	1.830	54.17	64.58	362	11.70	0.91	43.70	18.71	33.04	1.68	0.74	0.15
No. 5	0.952	1.709	44.58	45.92	650	12.02	1.00	42.40	19.43	33.84	1.71	0.74	0.15
No. 6	0.835	1.788	54.59	63.83	675	9.70	0.87	42.76	17.15	35.92	1.86	0.62	0.14
No. 7	0.842	1.805	55.75	69.00	487	12.40	1.10	42.00	21.50	34.00	1.10	0.35	0.12
Average	0.853	1.764	52.18	61.59	474	11.05	0.94	42.29	19.56	34.41	1.55	0.57	0.14

48-Hour Bee-Hive Coke Made From Pratt Washed Slack.

No. 8	0.951	1.793	46.94	49.36	537	11.20	1.05	44.00	24.00	27.74	2.50	0.40	0.12
No. 9	1.062	1.776	40.21	37.90	550	11.60	1.04	44.50	23.60	28.00	1.90	0.45	0.14
No. 10	1.060	1.816	41.24	38.64	540	10.80	0.98	44.60	22.50	28.30	2.00	0.30	0.11
No. 11	1.196	1.860	35.31	29.50	406	7.60	0.68	43.90	22.80	29.10	2.30	0.40	0.17
No. 12	1.013	1.855	45.40	44.78	575	11.30	0.92	43.74	24.25	29.51	2.65	0.50	0.11
No. 13	1.133	1.855	38.93	34.37	350	6.10	0.90	44.25	23.70	27.95	2.45	0.35	0.16
No. 14	0.982	1.857	47.14	48.03	488	9.50	1.00	44.60	24.30	27.35	2.10	0.40	0.18
No. 15	1.046	1.830	42.83	40.94	388	5.80	0.96	44.40	23.80	27.60	2.35	0.55	0.15
No. 16	1.114	1.870	39.20	34.10	375	7.25	0.98	44.00	23.65	27.55	1.98	0.62	0.17
No. 17	0.904	1.880	52.47	57.33	430	10.50	0.99	43.80	23.00	29.54	2.24	0.42	0.13
Average	1.046	1.839	42.96	41.49	464	9.16	0.95	44.17	23.56	28.26	2.24	0.43	0.14

TABLE VIII.—*72-Hour Bee-Hive Coke Made From Pratt Washed Slack.*

No.	Apparent Sp. grav.	True Sp. grav.	Per cent of cells by vol.	Vol. of cells in 100 parts by weight.	Comp. Strain Lbs. per square inch.	Ash.	Sulphur.
18	1.153	1.848	37.60	32.60	550	13.10	0.90
19	1.131	1.881	39.80	35.30	575	13.20	0.95
20	1.057	1.821	41.98	39.72	537	8.70	1.31
21	1.013	1.855	45.40	44.78	575	11.30	0.92
22	0.704	1.810	46.41	48.00	725	9.10	1.10
23	1.214	1.861	34.63	27.28	550	6.50	0.98
24	0.971	1.891	48.63	50.06	675	8.30	1.05
25	1.155	1.890	38.60	33.40	450	7.40	1.15
26	0.967	1.810	46.54	48.11	700	7.70	1.00
27	1.071	1.813	40.94	38.22	600	9.40	1.04
28	0.862	1.850	53.30	61.80	431	8.50	0.90
29	0.840	1.765	54.20	67.60	420	9.00	0.94
30	0.910	1.805	50.25	55.30	460	9.25	0.97
Aver.	1.003	1.838	44.48	44.77	558	9.34	1.02

48-Hour Disintegrated Pratt Nut. Not Washed.

31	0.866	1.667	48.00	55.34	325	11.55	1.30
32	0.812	1.359	40.55	49.62	400	14.02	1.40
Aver.	0.839	1.513	44.27	52.48	362	12.78	1.35

72-Hour Disintegrated Pratt Nut. Not Washed.

33	1.355	2.593	47.77	34.25	550	10.50	1.20
34	1.351	2.542	47.00	53.10	587	10.30	1.25
Aver.	1.353	2.567	47.38	43.67	568	10.40	1.22

TABLE IX.—48-*Hour Washed and Disintegrated Pratt Slack.*

No.	Apparent Sp. grav.	True Sp. grav.	Per cent of cells by vol.	Vol. of cells in 100 parts by weight.	Comp Strain Lbs. per square inch.	Ash.	Sulphur.
35	0.996	1.850	46.10	46.20	650	10.10	0.98
36	0.861	1.839	56.20	69.40	400	10.30	1.00
37	1.000	1.805	44.40	44.10	575	10.30	1.03
38	0.862	1.695	49.12	56.96	700	10.70	1.06
39	0.828	1.818	46.00	45.50	500	9.00	0.96
40	1.100	1.850	40.30	36.60	675	11.20	1.10
41	0.920	1.630	44.20	48.80	625	9.90	1.00
Aver.	0.938	1.784	46.62	49.65	589	10.12	1.02
72-Hour Washed and Disintegrated Pratt Slack.							
42	1.330	1.850	38.20	41.00	750	9.30	1.04
43	0.956	1.822	47.60	50.00	750	9.25	1.02
Aver.	1.143	1.836	42.90	45.50	750	9.27	1.03
48-Hour Black Creek Lump.							
44	0.900	1.84	46.20	52.00	400	3.90	0.79
72-Hour Milldale Lump.							
45	0.961	1.88	47.00	52.50	545	7.60	0.80
48-Hour Lewisburg Lump.							
46	0.84	1.764	52.46	62.54	531	10.20	0.68
Gas Carbon.							
47	1.25	2.10	40.50	43.00	600	5.90	1.23

These analyses show that the cokes examined fall into two main groups characterized by the porosity (cell space) and the size of the cells. On this basis of classification we have coke in which the percentage of cells by volume is just above 50 and coke in which this is just above 40. The first group includes the Blue Creek coke and the second the Pratt coke. The figures given in each case are averages from a number of determinations on separate pieces, not less than five and in most cases ten. For 48 hour Blue Creek coke made from washed slack the results were:

Apparent specific gravity	0.853
True specific gravity	1.764
Per cent. of cells by volume	52.18
Volume of cells in 100 parts by weight	61.59
Compressive strain	474 lbs.
Ash	11.05
Sulphur	0.94

For 48-hour Pratt coke made from washed slack the results were:

Apparent specific gravity	1.046
True specific gravity	1.839
Per cent. of cells by volume	42.96
Volume of cells in 100 parts by weight	41.49
Compressive strain	464 lbs.
Ash	9.16
Sulphur	0.95

There is a marked difference between these cokes, the one having a large cell and the other a small cell, while in strength they are about equal.

For determining the specific gravities and the cell space the method first proposed by Dr. T. Sterry Hunt, in 1863, and afterwards modified by Dr. F. P. Dewey, was used with some modifications. Instead of using the air pump, which does not seem to be necessary, the samples were boiled in water for 12 hours and allowed to stand in water for 12 hours longer before weighing. For the compressive strains one inch cubes were accurately cut from sound pieces of coke and bedded on leather. In each case at least three cubes were cut, care being taken to have them free from cracks and pieces of slate. They were crushed in a standard Riehle machine, operated by hand and reading to 3,000 pounds. The compressive strain was taken as one-fourth of the average pressure required to break the cubes. In some cases 72-hour and 96-hour coke was so strong that the cubes could not be broken at 3,000 pounds.

It must be understood in all discussions of the physical qualities of coke that great differences may be found in samples from the same oven and indeed in samples from the same part of the oven and from different parts of the same large piece of coke. Too much importance should not be attached to the results of the physical examination of coke unless the observations are continued over a considerable period on many separate samples. There is scarcely any product coming into use on so large a scale that varies so much in its physical qualities as coke. The size of the coal coked, the

amount of water it holds, the rapidity of the coking process and its duration, the quantity of water used in quenching and whether the quenching is done inside or outside of the oven, the depth of the bed of coal in the oven and the height of the crown above the bed are some of the factors which have to be considered.

The 72-hour bee-hive coke made from washed Pratt slack does not differ materially from the 48-hour product except in strength, 558 lbs. as against 464. It is especially adapted for foundry purposes, the increase of strength being of more importance in the cupola than in the blast furnace. In respect of strength the 48-hour unwashed, but disintegrated Pratt nut is much inferior to the 72-hour coke. The disintegration of unwashed Pratt nut coal, and subsequent coking, appears to yield a coke of about the same percentage of cells by volume as the 48-hour and 72-hour washed slack, but the volume of the cells is much larger, viz., as 53 to 41. The strength of the unwashed disintegrated Pratt nut coke of 48 hours is inferior to that of the 48-hour washed slack, while that of the 72-hour unwashed disintegrated nut is somewhat above the strength of the 72-hour washed slack. In other words, disintegrating the unwashed nut coal gave a coke of about the same percentage of cells by volume and increased the size of the cells, but failed to better the coke with respect to crushing strain.

Washed and disintegrated Pratt slack, whether 48-hour or 72-hour, makes a fine coke in every respect. In order to compare these cokes with standard Pennsylvania and Virginia cokes we append the results obtained by Mr. John Fulton and given in his excellent book on Coke.

Average Standard Connellsville Coke:

True specific gravity	1.77
Per cent. of cells by volume	45.87
Volume of cells in 100 parts by weight	54.13
Compressive strain	279 lbs.
Ash	10.58
Sulphur	0.81

Average of two samples from Big Stone Gap, Virginia:

True specific gravity	1.64
Per cent. of cells by volume	44.78
Volume of cells in 100 parts by weight	55.22
Compressive strain	285 lbs.
Ash	5.61
Sulphur	0.87

Pocahontas coke:

True specific gravity	1.83
Per cent. of cells by volume	52.07
Volume of cells in 100 parts by weight	47.93
Compressive strain	236 lbs.
Ash	5.88
Sulphur	0.73

Coke from Blocton, Ala.:

True specific gravity	1.75
Per cent. of cells by volume	49.97
Volume of cells in 100 parts by weight	50.03
Compressive strain	409 lbs.
Ash	6.94
Sulphur	0.74

The writer examined two samples of Blocton 48-hour beehive coke with the following results:

True specific gravity	1.65
Per cent. of cells by volume	44.46
Volume of cells in 100 parts by weight	45.98
Compressive strain	737 lbs.
Ash	5.80
Sulphur	1.35

A sample of Pocahontas (Stonega) coke gave:

True specific gravity	1.84
Per cent. of cells by volume	53.83
Volume of cells in 100 parts by weight	63.01
Compressive strain	588 lbs.
Ash	6.50
Sulphur	0.75

Coke from Earlington, Kentucky, 48-hour:

True specific gravity	1.69
Per cent. of cells by volume	53.47
Volume of cells in 100 parts by weight	67.67
Compressive strain	275 lbs.
Ash	14.60
Sulphur	1.74

Coke from Brookside, Ala., 72-hour washed slack.

True specific gravity	1.87
Per cent. of cells by volume	55.00
Volume of cells in 100 parts by weight	65.20
Compressive strain	320 lbs.
Ash	10.00
Sulphur	1.25

The average composition of the cokes used in the State is about as follows:

	Moisture Per Cent	Vol. and Combust. Matter Per Cent	Fixed Carbon Per Cent	Sulphur Per Cent	Ash Per Cent
Run of mines	0.75	0.75	84.50	0.90-1.60	14.00
Washed slack	0.75	0.75	88.50	0.80-1.10	10.00
Lump	0.75	0.75	87.00	1.00-1.30	11.50

Coke from recovery ovens, quenched on the outside and sent direct to the stockhouse may contain as much as 5 per cent. of moisture.

The composition of the ash of the cokes used is about as follows:

	Run of Mines Per Cent.	Washed Slack Per Cent.	Lump Per Cent.
Silica	47.03	45.10	46.00
Oxide of iron	12.46	12.32	12.00
Alumina	33.62	31.60	32.00
Lime	1.53	1.50	1.00
Magnesia	1.69	Trace	0.50
Sulphur	0.15	0.14	0.16

It would be interesting to know if the amount of ash and its composition influences the strength of the coke, or whether the treatment of the coal, prior to charging the ovens, and the duration and temperature of the coking process should alone be looked to.

If the coal were finely pulverized before charging the ovens there would be a more equable distribution of the ash-constituents, with consequent uniformity of composition. One

reason why washed slack makes such good coke is that the coal is comparatively fine when it goes to the ovens. There is a much better distribution of the ash-forming constituents of the coal and a more uniform product. By the previous washing a great part of the slate, bone, etc., has been removed and the thorough commingling of the coal particles ensures a more homogeneous product.

Uniformity of composition, however, desirable, does not necessarily imply increase of strength. A soft coke may have a uniform composition and yet be entirely unsuitable for blast furnace purposes.

If there is any one quality of coke which is of greater importance than any other to the iron maker it is strength. The coke must be strong enough to bear the grinding and torsional strains to which it is subjected during its descent in the furnace. It grinds upon itself and is also and to a much greater extent ground by the ore and the limestone. The dust made in this manner is lighter than the dust from the ore and the stone and is carried away by the blast and deposited in the dust-catchers (see analyses of flue dust.)

Some coals do not yield a strong coke unless they are pulverized. Whether this is due to the nature of the ash, its irregular distribution, the relation between the coking and the non-coking constituents of the coal, or to a number of causes acting among themselves, is not known. When such coals are pulverized they often make good coke. The composition of the ash may also affect the strength of the coke by altering the size and shape of the cells and the thickness of the cell-walls, for it is obvious that as the fusibility of the ash depends upon its composition, the reaction between the ash and the carbon are also a function of its composition. But of such matters not much is known.

The composition of the ash of coke, which is the composition of the ash of the coal accentuated, by concentration, has an important bearing on furnace practice and the quality of the pig iron produced. It has always to be taken into account in calculating burdens, for it affects the consumption of lime whether this be derived from limestone or from hard ore. The more acid the ash the more lime is required for fluxing it. In this State it is not a matter of great importance that the ash of the coke should be as free as possible from phos-

phorus, but where Bessemer pig iron is made a low-phosphorus coke is desired.

The amount of coke used per ton of iron varies, of course, with the nature of the coke and the other constituents of the burden; with the kind of iron made; with the size and shape of the furnace, the rate of driving and other circumstances usually grouped under the term "furnace practice." The range is from 1.16 tons (2598 pounds to 2 tons (4480 pounds) per ton (2240 pounds) of iron made. From an examination of the records covering 150,000 tons of iron made between the years 1890 and 1895, under varying conditions, the lowest consumption for a period of one month was 1.16 tons (2598 pounds). In this particular case the furnace was working on a burden of brown ore, the proportions being 52.9 per cent. of ore, 20.4 per cent of limestone and 26.7 per cent. of coke. The number of tons made per charge was 1.53, number of charges 1802, total iron made 2766 tons, of which 99.1 per cent. was of foundry grades. The consumption of materials per ton of iron was: ore 2.31 tons, stone 0.89 ton, coke 1.16 tons.

There was a case in which 1.72 tons of coke were used per ton of iron made. The furnace was running on a mixture composed of hard ore 53.7 per cent., soft ore 34.2 per cent. and brown ore 12.1 per cent. The entire burden was composed as follows; in percentages: hard ore 28.5, soft ore 18.2, brown ore 6.3, limestone 10.6 and coke 36.4. The iron made per charge was 1.88 tons, number of charges 1819, total iron made 3418 tons. The consumption of materials per ton of iron was, in tons of 2240 lbs.: Ore 2.51, stone 0.49, coke 1.72. On this burden the make of foundry irons was 92 per cent.

There has been a notable decrease in the consumption of coke per ton of iron since the extension of the practice of using coke made from washed slack. It is much superior to ordinary coke, both in structure and in composition. It could be still further improved by pulverizing the coal before charging the ovens. It would be of more uniform character and have also a greater strength.

No constituent of the burden responds so readily to variations in furnace practice as coke. It forms generally more than one-third of the burden and always more than one-half of the total cost of materials entering into a ton of iron is

chargeable to the coke. It is not only the most costly single ingredient, it is more costly than the ore and the stone, taken together. Economy in its use is, therefore, the most important one that can be undertaken in connection with the production of pig iron in this State.

A few years ago an investigation was undertaken by the writer for the purpose of studying the actual process of coking in a bee-hive oven.

The oven was of the usual bee-hive type, making one of a battery of 200. It was 12 feet in diameter, the spring of the arch beginning at 26 inches from the floor. The door was 2½ feet wide and 3 feet high. The trunnel-head was 14 inches deep and 14 inches in diameter. The weight of washed Pratt slack charged was 11,575 pounds, but as the coal contained 5 per cent of moisture the weight of dry coal was 11,024 pounds. After leveling, the top of the coal was 4 feet below the bottom of the trunnel-head. A charge of coke had just been drawn, so that the oven was hot. The door of the oven was taken down at the end of the 48th hour after charging, and the coke was watered inside the oven for 18 minutes. The oven was drawn by two men in one hour. The yield of coke over a fork of 14 tines, 21 inches wide, with spaces 1½ inches wide, in the clear, was 5,875.8 pounds, or 58.78 per cent. by weight of the dry coal charged. The weight of the dry breeze through the fork was 322 pounds, or 5.2 per cent. of the weight of the material from the oven and 5.48 per cent. of the coke over the fork.

The proximate analysis of the dry coal was, on dry basis:

	Per Cent.
Vol. and Combust. Matter	32.43
Fixed Carbon	60.91
Ash	6.66
	100.00

Sulphur, 1.91 per cent.

The analysis of the coke over the fork was, on dry basis:

	Per Cent.
Vol. and Combust. Matter	1.51
Fixed Carbon	88.90
Ash	9.59
	100.00

Sulphur, 1.37 per cent.

The analysis of the breeze and ashes passing the fork was, dry basis:

	Per Cent.
Vol. and Combustible Matter	1.47
Fixed Carbon	56.00
Ash	42.53
	100.00

Sulphur, 1.14 per cent.

The analysis of the black ends of the coke ("black jack") was:

	Per Cent.
Vol. and Combust. Matter	1.82
Fixed Carbon	89.00
Ash	8.18
	100.00

Sulphur, 1.29 per cent.

By screening the breeze and ashes over a 1-inch screen there was recovered 8 per cent. of material of the following composition:

	Per Cent.
Vol. and Combust. Matter	1.25
Fixed Carbon	88.40
Ash	10.35
	100.00

The 92 per cent (297 pounds from 322) which passed the 8-inch screen had the following composition.

	Per Cent.
Vol. and Combust. Matter	1.25
Fixed Carbon	61.40
Ash	37.35
	100.00

Sulphur, 0.83 per cent.

Passing the breeze and ashes over a ½ inch screen gave 35 per cent. over and 65 per cent. through the screen.

The analysis of these two products was as follows:

Over a ½ inch screen:

	Per Cent.
Vol. and Combust. Matter	1.20
Fixed Carbon	80.80
Ash	18.00
	100.00

Sulphur, 1.00 per cent.

Through a ½ inch screen:

	Per Cent.
Vol. and Combust. Matter	0.80
Fixed Carbon	51.90
Ash	47.30
	100.00

Sulphur, 0.80 per cent.

It does not appear to be advisable to use a finer fork than one with 1-inch spaces. With such a fork the yield of breeze and ashes from washed Pratt slack should not exceed 4.80 per cent of the total coke or 5 per cent of the coke over the fork. Under the best practice the loss in breeze and ashes should not exceed 4 per cent of the total amount of material drawn from the oven. The amount of this loss depends to a great extent upon the nature of the coal itself and the conduct of the process, but the skill of the coke-drawer and the manner in which the oven is watered are also important factors. Coke made from washed coal gives much less breeze than coke made from unwashed coal, the difference, at times, rising to as much as 50 per cent. in favor of the washed coal.

Another investigation was made at the same time with similar coal (washed Pratt slack) for 72-hour coke. The dry coal had the following composition, allowing for 5 per cent of moisture:

	Per Cent.
Vol. and Combust. Matter	32.55
Fixed Carbon	60.64
Ash	6.81
	100.00

Sulphur, 1.93 per cent.

Door of oven taken down after 72-hours. Time of watering, 17 minutes; time of drawing, two men, 55 minutes. Weight of dry coal charged 11,024 pounds; weight of dry coke obtained over 1½ inch fork 6590 pounds, or 59.7 per cent by weight of the dry coal charged. Weight of breeze and ashes 285 pounds, or 4.15 per cent of the weight of the material from the oven and 4.32 per cent of the coke over the fork.

The analysis of the coke over the fork was:

	Per Cent.
Vol. and Combust. Matter	1.71
Fixed Carbon	88.35
Ash	9.94
	100.00

Sulphur, 1.31 per cent.

The analysis of the black ends of this coke was:

	Per Cent.
Vol. and Combust. Matter	2.26
Fixed Carbon	86.52
Ash	11.22
	100.00

Sulphur, 1.28 per cent.

The analysis of the breeze and ashes was:

	Per Cent.
Vol. and Combust. Matter	1.09
Fixed Carbon	79.97
Ash	18.94
	100.00

Sulphur, 1.21 per cent.

Screening the breeze and ashes over a 1-inch screen gave 34 pounds of material on the screen and 251 pounds through the screen.

The analysis of the material on the screen (coke) was as follows:

	Per Cent.
Vol. and Combust. Matter	0.80
Fixed Carbon	87.64
Ash	11.56
	100.00
Sulphur, 1.28 per cent.	

The material passing the 1-inch screen had the following composition, dry:

	Per Cent.
Vol. and Combust. Matter	1.00
Fixed Carbon	69.90
Ash	29.10
	100.00
Sulphur, 1.10 per cent.	

A third investigation was made on this coal for 96-hour coke.

Weight of dry coal charged (allowing for 5 per cent. of moisture), 11,024 pounds. Analysis of coal, dry:

	Per Cent.
Vol. and Combust. Matter	32.46
Fixed Carbon	60.86
Ash	6.68
	100.00
Sulphur, 1.89 per cent.	

The door of the oven was taken down after 96-hours. Time of watering, 20 minutes; time of drawing, one man, 1 hour and 57 minutes. Yield of dry coke over 1½ inch fork 6350 pounds, or 54.86 per cent. of the dry coal charged. Weight of the breeze and ashes 240 pounds, or 3.64 per cent. of the weight of the material from the oven and 3.78 per cent. of the coke over the fork.

The analysis of the coke over the fork, was, dry:

	Per Cent.
Vol. and Combust. Matter	1.06
Fixed Carbon	89.63
Ash	9.31
	100.00
Sulphur, 1.34 per cent.	

Over a 1-inch screen there was recovered 14 pounds of material of the following composition, dry:

	Per Cent.
Vol. and Combust. Matter	1.56
Fixed Carbon	86.55
Ash	11.89
	100.00
Sulphur, 1.20 per cent.	

The material passing the 1-inch screen was not analysed.

The coal used in these three tests was washed Pratt slack of closely similar composition. Each "buggy" of coal was sampled as it was charged into the oven. In the following table, which embodies the above results, the composition of the coal is the average of the three analyses and all of the calculations are based on dry material.

TABLE X.—*Showing Chemical Changes from Coal to Coke. Proximate Analyses.*

	Vol. and Combust. Matter. Per Cent.	Fixed Carbon. Per Cent.	Ash. Per Cent.	Sulphur. Per Cent.	Yield of Coke. Per Cent.	Yield of breeze and ashes. Per Cent.	Inc. of carbon from coal to coke. Per Cent.	Inc. of ash from coal to coke. Per Cent.	Dec. of Vol. matter from coal to coke. Per Cent.	Dec. of sulphur from coal to coke. Per Cent.
Coal	32.48	60.80	6.72	1.91	--------	--------	--------	--------	--------	------
48-hour coke	1.51	88.90	9.59	1.37	58.78	2.92	46.21	42.71	95.35	28.27
72-hour coke	1.71	88.35	9.94	1.31	59.77	2.58	45.31	48.51	91.73	31.41
96-hour coke	1.06	89.63	0.31	1.34	57.51	2.17	47.41	38.54	96.73	29.84

In this table the yield of breeze and ashes is calculated as percentage of the dry coal charged into the oven.

The ultimate analyses of the coal, of the dense coke and of the needle coke were as follows:

	Coal Per Cent.	Dense Coke Per Cent.	"Needle Coke" Per Cent.
Carbon	78.23	84.55	97.55
Hydrogen	4.51	84.55	97.55
Oxygen	8.98	4.33	1.23
Nitrogen	1.56	0.18	----
Ash	6.72	9.61	0.10
	100.00	100.00	100.00
Sulphur	1.90	1.31	0.27

The average yield of dry coke over a 1½ inch fork was 58.69 per cent. The average increase of the fixed carbon was 46.31 per cent. and of the ash 43.25 per cent. The average decease of the volatile and combustible matter was 95.94 per cent. and of the sulphur 29.84 per cent.

The 48-hour, 72-hour and 96-hour coke from this investigation were examined for specific gravity, cell space and strength. The results appear in the following table:

TABLE XI.—*Specific Gravity, Cell Space and Strength of* 48. 72 *and* 96-*hour Cokes.*

	Appar. Sp. Grav.	True Sp. Grav.	Per cent. of cells by vol.	Vol. of cells in 100 parts by weight.	Compressive strain ¼ ultimate breaking strength.
48-hour	1.029	1.913	46.58	46.29	440 pounds.
72-hour	0.875	1.785	52.22	61.45	550 pounds.
96-hour	0.921	1.839	48.84	54.30	660 pounds.

Four other tests were made to determine the yield of coke and refuse (breeze and ashes) from washed Pratt slack not disintegrated and washed Pratt slack disintegrated. The results are as follows:

Washed Pratt slack: Charged coal (6 per cent. of moisture) 12,650 pounds, obtained 72-hour coke, over 1½ inch fork, 7,080 pounds (=55.96 per cent.) and refuse 348 pounds (=2.75 per cent.)

Washed Pratt slack: Charged coal (6 per cent. of moisture) 13,150 pounds, obtained 72-hour coke 7725 pounds (=58.74 per cent.) and 346 pounds of refuse (=2.63 per cent.)

Disintegrated washed Pratt slack: Charged coal (6 per cent. of moisture) 11,000 pounds, obtained 72-hour coke 6715 pounds (=61.04 per cent.) and 271 pounds of refuse (=2.46 per cent.)

Disintegrated washed Pratt slack: Charged coal (6 per cent. of moisture) 11,300 pounds, obtained 72-hour coke 7275 pounds (=64.38 per cent.) and 230 pounds of refuse (=2.04 per cent.)

In this test the disintegration of the coal gave a considerable increase in the yield of coke and there was less waste in the refuse. The coke was stronger and denser than usual.

For producing the best possible coke from almost any given coal it should be washed and disintegrated, the coal being pulverized to pass a ¼ mesh screen. Next below this in quality would be coke made from washed but not disintegrated coal, then lump, nut and run-of-mines.

By comparing the proximate composition of the coal and the coke with the ultimate composition several interesting things are observable. What is termed "fixed carbon" in the proximate analysis of coal is a very different thing from the carbon obtained on combustion, being in the one case 60.80 and in the other 78.23. In the proximate analysis the fixed carbon is considered to be the difference between 100 and the sum of volatile matter and ash, on a dry basis. If the volatile matter is 32.48 and the ash is 6.72 the fixed carbon is $100-(32.48+6.72)=60.80$. Under ordinary conditions, when using washed Pratt slack, we may expect to find an increase of about 46 per cent. in the fixed carbon, as between the coal and the coke while at the same time the ash increases about 43 per cent. In the coal there are two volatile ingredients, moisture and volatile hydrocarbons, and two fixed ingredients, fixed carbon and ash. But in driving off the volatile matter, even in a covered platinum crucible enclosed within another covered crucible, there is a serious loss of carbon, because the volatile matter itself is composed of gaseous hydrocarbons and solid carbon, as smoke. The soot is not pure carbon, but contains hydrocarbon compounds whose nature

varies according to circumstances, such as the rapidity of the heating, the duration of the heat and the nature of the coal itself. There are numerous scientific questions of the greatest interest involved in the change from coal to coke, but from a practical stand-point there is but one important question in so far as concerns the amount of the fixed carbon, viz: Can any of the volatile hydrocarbons, reckoned as such in the ordinary proximate analysis, be used during the coking process as a source of carbon? Are there chemical or chemico-physical reactions within the oven which enable the vaporous hydrocarbons to pass into the solid condition, by decomposition?

It is well known that certain hydrocarbons evolved from coal at a comparatively low temperature are decomposed at a higher temperature with deposition of carbon. Olefiant gas, C_2H_4, and acetylene, C_2H_2, are instances, the latter gas decomposing, under certain conditions, at ordinary temperatures. But according to the researches of Fyfe, published several years ago in the Journal of Gas Lighting, olefiant gas and acetylene occur in the gases evolved in the destructive distillation of coal only in a few tenths of a per cent. Ebelmen found that after being in the oven for 7½ hours a coal on which he was experimenting gave only 1.66 per cent. of olefiant gas. The following table is taken from the researches of this distinguished chemist and gives the composition of gas taken from an oven which was not recovering by-products.

TABLE XII.—*Composition of Coke Oven Gas—Ebelmen.*

	After 2 hours	After 7½ hours	After 14 hours	Mean
Carbonic acid	10.13	9.60	13.06	10.93
Olefiant gas	1.44	1.66	0.40	1.17
Hydrogen	6.28	3.67	1.10	3.68
Carbonic oxide	4.17	3.91	2.19	3.42
Nitrogen	77.98	81.16	83.25	80.80

The composition of coke oven gases varies a good deal and seems to depend not only upon the nature of the coal itself but also upon the rapidity of the process, the thickness of the bed of coal, the size of the coal charged, the amount of air entering the oven, etc.

Furthermore, changes are continually in progress within the oven itself from the time when the coal becomes hot enough to evolve gases until the coke is watered and drawn. These changes are not necessarily the same in kind or in de-

gree throughout the coking mass. At one point decomposable gases are being evolved, at another they are depositing carbon, at a third non-decomposable gases—non-depositing gases—are coming off, at a fourth gases are being evolved which under proper conditions might deposit carbon but which are escaping into the air.

It is probable that reactions going on within the mass of burning coal and within the mass of red-hot coke allow some of the hydrocarbons to deposit carbon, but it is almost impossible to estimate how much of this deposited carbon there may be in any one oven.

The bright silvery needles and blades found on bee-hive coke are composed of almost pure carbon, combustion giving from 97.50 to 98.50 per cent. But these blades and needles form an insignificant proportion of the coke itself and seem to enhance the appearance of the coke without adding materially to its weight. The writer has had opportunity of securing some fine specimens of deposited carbon from a bee-hive oven. Some large lumps of limestone were thrown in on top of the charge to make a little lime that was needed at the time. When the oven was ready to draw they were removed before the water touched them. The lumps of limestone were not mixed with the coal but lay loosely upon the surface. When they were removed they were full of cracks and many of these cracks were lined with sheets of almost pure carbon. The sheets were as thick as ordinary letter paper and were somewhat flexible. There were countless little fused globules of bright, silvery carbon scattered all over the sheets and under a 1/8 inch objective these globules were seen to be covered with a net work of fine lines, running hither and thither. On illuminating the globules with a focussing glass in bright sun-light they presented a most beautiful appearance under the microscope, resembling great globes of purest silver floating in dense blackness.

Hair-coke, the so-called "whiskers" of the coke-burner, are also composed of almost pure carbon and under a 1/12 inch objective are often seen to be covered with minute globules adhering to the sides of the hair and looking like pearls strung on a silver wire. Now and then these hairs are covered with little curved projections, while again they resemble a thread partially untwisted so that the separate strands are

visible. Occasionally they are pierced through by minute holes, a high magnifying power showing several holes in lines across the hair.

Percy speaks of the hair-like form of coke and supposes that the hairs are carbon tubes blown out by the escaping gases. The hairs are sometimes completely filled with carbon, by interior deposition, but they are also often hollow, as the writer has observed.

It is possible that the deposited carbon counterbalances, to some extent, the carbon burned in the oven. This pre-supposes that the fixed carbon of the coal is of the same nature as the fixed carbon of the coke; a supposition not always tenable. When the volatile matter of coal is driven off in a platinum crucible, over a blast-lamp, some deposited carbon may always be found, for the coke thus obtained exhibits the bright, silvery luster and the reticulated markings characteristic of deposited carbon. The conditions favorable to the deposition of carbon are more abundant and more pronounced in a coke oven than in a crucible and it is likely that the coke from an oven has relatively much more deposited (and therefore very pure) carbon than the residue in a crucible after driving off the volatile matter.

If we are correct in assuming that deposited carbon enhances the appearance of bee-hive coke, making it more silvery and of a distinctively brighter color, it should be the purpose of the coke-burner to increase the proportion as much as possible. Furthermore, although positive evidence on this score is lacking, it is possible that deposited carbon, lining, as it does the cell-walls of the coke, is an active agent in preventing the decomposing action of carbonic acid on coke. It has been proposed by Sir Lowthian Bell to value coke for blast furnaces purposes by its resistance to carbonic acid and Thoerner has suggested hydrogen for the same purpose. It is known that cokes differ a good deal in respect to this resisting power and that the higher this power the more stable is the coke, *ceteris paribus.*

But carbonic acid is not the only gas which may affect the stability of coke in the blast furnace. We have to do also with the other constituents of blast furnace gas, such as carbon monoxide, hydrogen, methane, oxygen, nitrogen and aqueous vapor, all at high temperatures. The solvent power

of carbonc acid on coke when it is used alone may be a very different thing from its solvent power when in admixture with other gases. It is not altogether safe to assume that because a certain coke stands up well under the action of carbonic acid it will exhibit similar resistance under the widely differing conditions which maintain in actual practice.

Considering the importance of the subject it is surprising that so little is known concerning the physical qualities of coke and how these are modified by the forces at work within the furnace.

ALABAMA COAL IN BY-PRODUCT (RECOVERY) OVENS.

In the second edition of this book there was given an abstract from a report made by the writer to the Sloss Iron & Steel Company on the results of testing 54,000 pounds of washed Pratt slack in the ovens of the Pittsburg Gas & Coke Company, near Glassport, Penna. Since that time a great deal of experience has been accumulated by the Semet-Solvay Co. at its Ensley and Holt works on the practical working of Alabama coals in the by-product oven.

The test at Glassport was made in Otto-Hoffman ovens, each holding about 7.5 tons of coal. The proximate analysis of this coal was made by Drs. Mason & Luthy, the ultimate analysis was made by the writer.

Composition of Washed Pratt Slack Coal used in Coking tests, Otto-Hoffman Ovens.

	Per Cent.
Moisture	5.95
Vol. and Combust. Matter	32.69
Fixed Carbon	54.33
Ash	7.03
	100

Sulphur, 0.94; Phosphorus, 0.0117.

Ultimate analysis. Dry basis:

Carbon	76.50
Hydrogen	4.90
Oxygen	10.15
Nitrogen	1.25
Ash	7.20

This amount of nitrogen is equivalent to 1.51 per cent. of ammonia, N. H_3. The disposable hydrogen is 3.61 per cent.

The first charge contained 13,067 pounds of dry coal, coking time 34 hours, 35 minutes. The coke was rammed out in one minute and watered on the outside. When ready to load the coke contained 1.80 per cent. of moisture. The yield of dry coke, over a 1½ inch fork, was 8.490 pounds, or 64.9 per cent. of the weight of the dry coal. The dry breeze weighed 320 pounds (=2.45 per cent. of the weight of the dry coal). The total weight of coke obtained was 8,810 pounds, of 67.3 per cent. of the weight of the dry coal.

The yield of sulphate of ammonia was 19.2 pounds per ton of dry coal. The average specific gravity of the gas was 0.471. The highest candle power observed was 18.8 and the average was 13.2. The highest B. T. U. was 748, the average being 651.8. The yield of tar from the separate charges was not determined, the total weight having been taken at the close of the test.

The second charge contained 13,509 pounds of dry coal, coking time 29 hours, and 30 minutes. When ready to load the coke contained 3 per cent. of moisture. The yield of dry coke, over the fork, was 9,275 pounds, or 68.6 per cent. of the dry coal. The dry breeze weighed 582 pounds (=4.30 per cent.) The total yield of coke was thus 9,857 pounds, or 72.9 per cent. The yield of sulphate of ammonia was equivalent to 23.9 pounds per ton of dry coal. The average specific gravity of the gas was 0.411. The highest candle power observed was 16.3, the average being 11.1. The highest B. T. U. was 744.4, the average being 602.1.

The third charge contained 13,882 pounds of dry coal, coking time 30 hours and 5 minutes. When ready to load the coke contained 3.0 per cent. of moisture. The yield of dry coke, over the fork, was 9020 pounds, or 65.4 per cent. and of breeze 600 pounds, or 4.3 per cent. The total yield of coke was thus 9,620 pounds, or 69.7 per cent. The yield of sulphate of amonia was 26.9 pounds per ton of dry coal. The average specific gravity of the gas was 0.454. The highest candle power observed was 17.8 and the average was 11. The highest B. T. U. was 782.1, the average being 618.1.

The fourth charge contained 14,171 pounds of dry coal, coking time 32 hours and 20 minutes. When ready to load the coke contained 4.30 per cent. of moisture. The yield of dry coke, over the fork was 9,608 pounds, or 67.8 per cent., and of dry breeze 708 pounds (5.0 per cent.) The total yield of coke was 72.8 per cent. The yield of sulphate of ammonia was 25.5 pounds per ton of dry coal. The average specific gravity of the gas was 0.426. The highest candle power observed was 12.6, the average being 10.3. The highest B. T. U. were 739.6, the average being 648.8.

Considering these results as a whole we find that the average amount of moisture in the coke when ready to load was 3.02, the average yield of dry, forked coke was 66.7 and of breeze 4.0 per cent., a total yield of 70.7 per cent. The average yield of sulphate of ammonia was 23.9 pounds per ton of dry coal. The highest candle power was 18.8 and the average was 11.4. The highest B. T. U. were 782, the average being 630.2. The yield of tar was 90 pounds per ton of dry coal. The average quality of the tar was as follows:

	Sp. Grav.	Moisture.	Oil.
From the seal-pot	1.211	3.93	1.52
From the exhauster	1.211	2.04	2.04

The average composition of the coke was:

	Per Cent.
Vol. and Combust. Matter	0.98
Fixed Carbon	90.22
Ash	8.80
	100

Sulphur, 1.28 per cent.

TABLE XIII.—*Showing Results of Test on Washed Pratt Slack. Otto-Hoffman By-Product Ovens.*

	Dry Coal Charged Pounds	Yield of Coke				Sulphate of Ammonia per ton of dry coal, Lbs.	Tar, per ton of dry coal, Lbs.	Coking time per charge		Average B. T. U. of gas.	Average candlepower of gas.
		Over 1½ inch fork		Through 1½-in. fork.							
		Lbs.	Pr. Ct.	Lbs.	Pr. Ct.			hrs.	mins.		
1st Charge	13,067	8,490	64.9	320	2.45	19.2	*	34	35	651.8	13.2
2d Charge	13,509	9,275	68.6	582	4.30	23.9	*	29	30	744.4	11.1
3d Charge	13,882	9,020	65.4	600	4.30	26.9	*	30	5	618.1	11.0
4th Charge	14,171	9,608	67.8	708	5.0	25.5	*	32	20	648.8	10.3
Total and Average	54,629	36,393	66.6	2,212	4.05	23.9	90	31	30	665.7	11.4

*The yield of tar from all charges was 360 lbs.

Excluding the breeze and ashes the yield of coke over a 1½ inch fork was, on the average, 66.6 per cent. of the weight of the dry coal charged. This yield is from 6 to 8 per cent. greater than the yield from a bee-hive oven. In other words, under the conditions of ordinary practice we get from 100 tons of coal 58 to 60 tons of coke over the fork from a bee-hive oven and from 64 to 66 tons from the by-product oven. The average daily output of a bee-hive oven holding 6 tons of coal is 1.74 tons of coke. The average daily output of one of the new five-high retort ovens, holding 11 tons of coal, is 7.2 tons of coke. In other works, one retort-oven is equivalent to 4.1 bee-hive ovens. The cost of the four bee-hive ovens would be about $2400.00, the cost of the retort oven would be about $8000.00, so that the construction cost of the retort oven is about 3 1/3 times that of the bee-hive oven. Against this difference in cost is to be placed the value of the three additional products, heating and illuminating gas, ammonical liquors and tar. In so far as concerns its commercial status the by-product oven appears to depend for its success, upon two considerations:

First—The plant must be so situated as to dispose readily of the by-products.

Second—It must be able to make good coke from coal which does not make good coke in the bee-hive oven.

From the ordinary bee-hive oven there is obtained only one product, viz., coke, although at some places the hot gases are used for generating steam. From the by-product ovens there are obtained four products, viz., coke, tar, ammonical liquors (from which sulphate of ammonia is made), and gas suitable both for heating and for illuminating purposes.

The yield of coke is considerably greater in the by-product oven than in the bee-hive but there seems still to be some doubt whether the efficiency of the coke as a blast furnace fuel is as great as that of bee-hive coke. Some observers have placed the difference at 10 per cent. in favor of the bee-hive coke while others think that it is about 7 per cent. Others, on the contrary, held that there is little or no difference between them, per unit of carbon.

With respect to the relative value of bee-hive and by-product coke in the blast furnace and in the cupola, no fairer statement of the case can be made than appears in a recent article contributed by Mr. W. H. Blauvelt, consulting engineer for the Semet-Solvay Company, Syracuse, N. Y., to the Transactions of the American Society of Mechanical Engineers.

Mr. Blauvelt said:

"There is some difference of opinion among furnacemen as to the relative value of the two cokes in the blast furnace, owing to differences in individual experiences. Retort-oven coke has received a gerat deal of criticism in this country because much coke has been made from coal which would be quite out of the question for use in the bee-hive oven. The reasons for using such coals were doubtless satisfactory to the management of the oven plants, but the coke produced was often held up for comparison with Connellsville bee-hive coke, which is, perhaps, the very best bee-hive product in the world. There are so many different grades of retort and bee-hive coke produced from the different coals, and under different conditions in the several plants in operation, that a comparison of the two general types of coke is practically an im-

possibility. Some of the best furnace work in this country has been done with retort coke, which would seem to justify the statement that the best retort coke is as good as the best bee-hive coke in the blast furnace.

In the foundry cupola retort-oven coke has an exceptional record, and in some localities it is without question the standard of foundry coke."

Be this as it may, the successful operation of the by-product oven seems to depend largely upon a ready sale for the by-products. The utilization of the surplus gas from a by-product plant, amounting to about 3000 cubic feet per ton of coal coked, is possible only when the plant is within easy reach of consumers of gas, such as a large blast furnace or steel plant or a large city. The sulphate of ammonia, made from the ammonical liquors, is a valuable ingredient of commercial fertilizers and is also used as a source of other ammonia compounds, anhydrous ammonia, etc. The market for tar (and pitch) may be enlarged through the extension of the use of lignite, as a binder in briquetting. Tar also makes an excellent fuel under steam boilers. In Alabama the tar may come into use in briquetting ore concentrates, although nothing is being done in this direction at present.

The following table, taken from the reports of Mr. E. W. Parker, of the United States Geological Survey, gives a bird's-eye view of the coke industry in Alabama since 1880:

TABLE XIV.—*Coke Ovens in Alabama. Tons of 2000 pounds.*

	Establishments.	Ovens		Coal used, Tons	Coke produced, Tons	Yield of Coke Per cent.	Value of Coke	
		Built	Building				Total	Per ton
1880	4	316	100	106,283	60,781	57	$183,063	$3.01
1881	4	416	120	184,881	109,033	59	326,819	3.00
1882	5	536	------	261,839	152,940	58	425,940	2.79
1883	6	767	122	359,699	217,531	60	598,473	2.75
1884	8	976	242	413,184	244,009	60	609,185	2.50
1885	11	1,075	16	507,934	301,180	59	755,645	------
1886	14	1,301	1,012	635,120	375,054	59	993,302	2.65
1887	15	1,555	1,362	550,047	325,020	59	775,090	2.39
1888	18	2,475	406	848,608	508,511	60	1,189,579	2.34
1889	19	3,944	427	1,746,277	1,030,510	59	2,372,417	2.30
1890	20	4,805	371	1,809,964	1,072,942	59	2,589,447	2.41
1891	21	5,068	50	2.144,277	1,282,496	60	2,986,242	2.33
1892	20	5,320	90	2,585,966	1,501,571	58	3,464,623	2.31
1893	23	5,548	60	2,015,398	1,168,085	58	2,648,632	2.70
1894	22	5,551	50	1,574,245	923,817	58.7	1,871,348	2.25
1895	22	5,658	50	2,459,465	1,444,339	58.7	3,033,521	2.10
1896	24	5,363	------	1,769,820	1,038,707	58.7	2,181,284	2.10
1697	25	5,365	120	2,451,475	1,443,017	58.8	3,094,461	2.14
1898	25	5,456	100	2,814,615	1,663,020	59	3,378,946	2.03
1899	25	5,599	850	3,028,472	1,787,809	59	3,634,471	2.03
1900	30	6,529	690	3,582,547	2,110,837	58.9	5,629,423	2.66
1901	31	7,136	535	3,849,908	2,148,911	55.8	6,062,616	2.82
1902	37	7,571	1,334	4,237,491	2,552,246	60.2	8,300,838	3.25
1903	39	8,764	381	4,483,942	2,693,497	60	7,622,528	2.83
1904	42	9,059	440	3,996,578	2,340,219	58.6	5,716,413	2.44
1905	42	9,586	154	4,409,854	2,576,986	58.4	7,646,957	2.96
1906	42	9,731	160	5,184,597	3,034,501	58.5	8,477,899	2.79
1907	43	9,889	50	4,973,296	3,021,794	61.0	9,216,194	3.05
1908	45	10,103	------	3,875,791	2,362,666	61.0	7,169,901	3.04
1909	43	10,061	------	5,080,764	3,085,824	60.7	8,068,267	2.61
1910	43	10,132	340	5,272,322	3,249,027	61.6	9,165,821	2.82
1911	44	10.121	280	4,411,298	2,761,521	62.6	7,593,594	2.75

The following table, taken from the same source, gives the character of the coal that has been used for making coke in Alabama:

TABLE XV.—*Character of Coal Used in Making Coke in Alabama. Tons of 2000 pounds.*

	Run of Mines				Slack			
	Unwashed		Washed		Unwashed		Washed	
	Tons	Per Cent	Tons	Per Cent	Tons	Per Cent	Tons	Per Cent
1890	1,480,669	81.8	--------	-----	206,106	11.3	123,189	6.9
1891	1,943,469	90.6	--------	-----	192,238	9.0	8,570	0.4
1892	2,463,366	95.3	--------	-----	11,100	0.4	111,500	4.3
1893	1,246,307	61.8	51,163	2.5	292,198	14.6	425,730	21.1
1894	411,097	26.1	7,429	0.5	477,820	30.3	677,899	43.1
1895	1,208,020	49.1	--------	-----	32,068	1.3	1,219,377	49.6
1896	1,292,191	50.2	70,125	2.7	51,674	2.0	1,159,723	45.1
1897	902,310	36.8	120,420	4.9	91,200	3.8	1,337,545	54.5
1898	1,290,794	45.8	828,294	29.4	25,600	1.0	670,527	23.8
1899	1,656,226	54.6	725,238	23.9	9,898	0.5	637,110	21.0
1900	1,729,882	48.3	152,077	4.2	165,418	4.7	1,535,170	42.8
1901	1,641,830	42.9	491,298	12.8	17,796	0.2	1,698,984	44.1
1902	1,233,117	29.1	509,376	12.0	290	-----	2,494,708	58.9
1903	1,359,450	30.3	602,446	13.4	--------	-----	2,522,046	56.3
1904	670,271	16.7	922,864	23.1	741	-----	2,402,702	60.2
1905	1,297,376	29.4	1,247,924	28.3	--------	-----	1,864,554	42.3
1906	1,493,549	28.8	1,810,089	34.9	121,122	2.4	1,759,837	33.9
1907	1,020,907	20.5	1,697,913	34.1	27,433	.5	2,227,043	44.9
1908	548,093	14.1	1,457,360	37.6	53,218	1.3	1,817,120	47.0
1909	713,992	14.1	2,153,801	42.4	--------	-----	2,212,971	43.5
1910	771,931	14.6	1,308,085	24.8	--------	-----	3,192,306	60.6
1911	693,135	15.7	1,295,109	29.3	2,937	-----	2,420,117	55.

In this connection it might be of interest to give the annual coal production of Alabama since 1840, as compiled by Mr. Parker:

TABLE XVI.—*Annual Coal Production of Alabama, 1840-1910. Tons of 2000 pounds.*

Year	Production	Year	Production	Year	Product.
1840	946	1864	15,000	1888	2,900,000
1841	1,000	1865	12,000	1889	3,572,983
1842	1,000	1866	12,000	1890	4,090,409
1843	1,200	1867	10,000	1891	4,759,781
1844	1,200	1868	10,000	1892	5,529,312
1845	1,500	1869	10,000	1893	5,136,935
1846	1,500	1870	11,000	1894	4,397,178
1847	2,000	1871	15,000	1895	5,693,775
1848	2,000	1872	16,800	1896	5,748,697
1849	2,500	1873	44,800	1897	5,893,770
1850	2,500	1874	50,400	1898	6,535,283
1851	3,000	1875	67,200	1899	7,593,416
1852	3,000	1876	112,000	1900	8,394,275
1853	4,000	1877	196,000	1901	9,099,052
1854	4,500	1878	224,000	1902	10,354,570
1855	6,000	1879	280,000	1903	11,654,324
1856	6,800	1880	323,972	1904	11,262,046
1857	8,000	1881	420,000	1905	11,866,069
1858	8,500	1882	896,000	1906	13,107,963
1859	9,000	1883	1,568,000	1907	14,250,454
1860	10,200	1884	2,240,000	1908	11,604,593
1861	10,000	1885	2,492,000	1909	13,703,450
1862	12,500	1886	1,800,000	1910	16,111,462
1863	15,000	1887	1,950,000		

Total production, 1840 to 1910, 206,109,332 tons.

TABLE XVII.—*Coal Production in Alabama* 1889-1910.

COUNTY	1889	1890	1891	1892	1893	1894	1895
Bibb	500,525	221,811	619,809	793,469	806,214	401,061	653,732
Blount	---------	---------	---------	---------	---------	8,000	62,400
Etowah	---------	---------	---------	---------	---------	---------	900
Jefferson	2,437,446	2,665,060	2,905,343	3,399,274	3,093,277	2,766,302	3,726,325
St. Clair	40,557	33,653	66,096	24,950	72,000	43,517	30,806
Shelby	84,333	25,022	34,130	27,968	55,339	76,619	52,754
Tuscaloosa	16,141	65,517	142,184	168,039	167,516	191,081	208,117
Walker	488,226	767,346	980,219	1,103,612	927,349	891,953	946,241
Winston	---------	---------	---------	---------	3,200	4,634	4,500
Small Mines	5,255	12,000	12,000	12,000	12,000	8,000	8,000
Total	3,572,983	4,090,409	4,759,781	5,529,312	5,136,935	4,397,178	5,693,775

COUNTY	1896	1897	1898	1899	1900	1901	1902
Bibb	710,842	671,077	810,891	912,263	964,785	1,258,853	1,487,407
Blount	32,760	40,518	18,300	64,951	18,572	143,697	253,178
Etowah	3,080	---------	5,884	9,578	20,855	93,591	101,790
Jefferson	3,729,719	3,714,676	4,204,590	4,878,696	5,255,296	5,549,715	5,855,536
St. Clair	33,368	67,584	72,808	---------	156,270	140,816	156,243
Shelby	52,923	84,673	68,987	86,928	135,832	149,132	136,043
Tuscaloosa	205,223	234,468	238,954	325,461	268,422	374,718	431,711
Walker	952,642	1,037,516	1,071,334	1,249,294	1,489,380	1,284,025	1,903,976
Winston	2,140	8,238	8,535	10,825	49,863	69,505	28,686
Small Mines	25,000	35,000	35,000	35,000	35,000	35,000	---------
Total	5,748,697	5,893,770	6,535,283	7,593,416	8,394,275	9,099,052	10,354,570

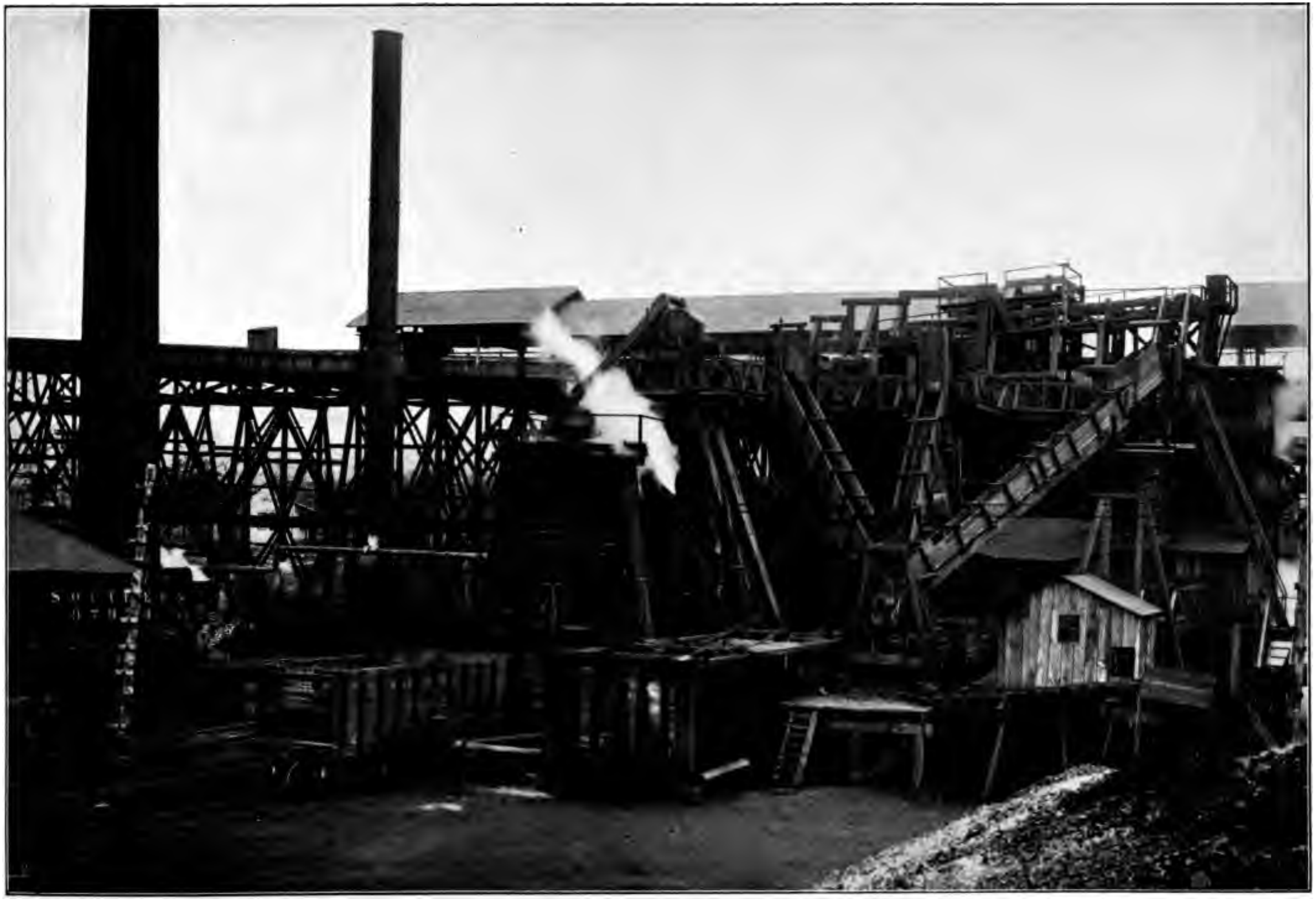
COUNTY	1903	1904	1905	1906	1907	1908	1909	1910
Bibb	1,651,157	1,386,079	1,335,923	1,324,656	1,297,158	1,166,548	1,338,243	1,580,564
Blount	260,802	279,070	294,550	---------	---------	---------	---------	---------
Etowah	119,830	128,989	170,484	133,660	205,015	8,880	46,194	172,465
Jefferson	6,194,832	5,821,663	5,873,268	6,623,115	7,487,278	5,914,129	7,176,922	8,298,702
St. Clair	152,313	144,223	186,595	256,227	283,806	193,434	354,005	428,409
Shelby	240,962	128,307	157,569	225,087	284,084	407,547	524,925	488,141
Tuscaloosa	610,392	663,412	885,361	1,050,792	1,047,364	712,101	1,006,989	1,081,219
Walker	2,365,385	2,583,473	2,845,617	3,062,518	3,254,919	2,941,836	2,973,776	3,788,479
Winston	50,841	40,356	40,109	27,076	35,333	28,408	32,278	16,442
Small Mines	7,810	---------	1,360	1,500	482	650	460	310
Other Counties*	*	*86,474	*369,783	*403,332	*355,015	*231,060	249,658	256,731
Total	11,654,324	11,262,046	11,866,069	13,107,963	14,250,454	11,604,593	13,703,450	16,111,462

*Blount, Cullman, Jackson, Marion, DeKalb.

NOTE—In 1894 Jackson county produced 6,011 tons of coal; in 1897 the production for Blount county includes also that of Etowah county; in 1898, 1900 and 1901 the production in Blount county includes also that in Cullman county; in 1899 the production in Blount county includes also that in St. Clair county; in 1902, 1903 and 1905 the production in Blount county includes also that in Cullman and Marion counties; in 1904 other counties, including Jackson and DeKalb produced 86,474 tons and 76,593 tons in 1905; in 1900 and 1901 the production in Winston county includes also that in Marion county; in 1899 the production in Cullman and Marion counties was 20,420 tons.

From 1889 to and including 1910 the total production of coal was 193,422,995 tons. Of this amount Bibb county produced 21,913,067 tons, or 11.3 per cent.; Jefferson county produced 107,571,164 tons, or 55.00 per cent.; Walker county produced 38,909,116 tons, or 20.10 per cent. These three counties have produced, during this period of 22 years 86.4 per cent. of the entire coal production of the State. During this period the average value of the coal at the mines was per ton: in Bibb county, $1.27; in Jefferson county, $1.13; and in Walker county, $1.10. During the last 22 years 86.4 per cent. of the coal mined in Alabama was worth, per ton at the mines, from $1.10 to $1.27, on the average. The maximum average value, per ton, was $1.52 and the minimum 69 cents, both from Jefferson county.

Plates XV and XVI show two representative coal washers of the Birmingham District.



Washer and Tipple, Sayreton, Jefferson County. Republic Iron and Steel Company.

COAL WASHER AND TIPPLE, TWO WASHERS IN ONE PLANT, HANDLING TWO DIFFERENT KINDS OF COAL, ACMAR, ST. CLAIR COUNTY.
ALABAMA FUEL AND IRON COMPANY.

CHAPTER VII.

COKE FURNACES.

CONDITION, CAPACITY AND PRODUCTION.

On July 1st, 1907, there were 44 coke furnaces in Alabama, of which 31 were in blast and 13 were out of blast.

On the first of January, 1882, there were four furnaces in blast, with a weekly capacity of 1,200 tons. Ten years later these had increased to 38 and the weekly capacity had risen to 25,238 tons. On the first of January, 1902, there were 39 furnaces, with a weekly capacity of 34,934 tons. The era of furnace building in Alabama was between the years 1882 and 1892, thirty-four furnaces having been built during this period and the weekly capacity increased by 24,000 tons. Since 1892 there have been added six furnaces and the weekly capacity has been increased by 9,696 tons. The total production of coke iron in 1882 was 51,101 tons, which was 81.9 per cent. of the entire yearly capacity. In 1892 the production was 835,840 tons, or 63.5 per cent. of the entire capacity. In 1906 the production was 1,649,018 tons, or 65.8 per cent. of the entire capacity. If all of the furnaces had been run up to their capacity during 1906 the production of pig iron would have been 2,506,244 tons instead of 1,649,018 tons. Under such conditions as have maintained during the last few years it is not likely that the production will be more than 70 per cent. of the capacity. The reduction is due to furnaces being out of blast for re-lining, remodeling, etc., to labor conditions, etc.

TABLE XVIII.—*Condition, Weekly Capacity and Production of Coke Iron Furnaces in Alabama,* 1882-1910. *Tons of* 2240 *pounds.*

Year.	Total.	In.	Weekly capacity, tons.	Out.	Weekly capacity, tons.	Production: tons.	
Jan'y 1st., 1882 } July 1st, }	4	4	1,200	---	------	Entire year	51,101
Jan'y 1st., 1883	9	4	1,520	5	3,400	1st. half	32,590
July 1st	9	4	2,100	5	2,820	2nd half	70,176
Jan'y 1st., 1884	9	6	3,500	3	920	1st half	54,034
July 1st	9	4	2,390	5	2,110	2nd half	62,248
Jan'y 1st., 1885	10	6	3,490	4	1,160	1st half	76,586
July 1st.	10	8	4,220	2	370	2nd half	56,243
Jan'y 1st., 1886	10	7	3,820	3	770	1st half	96,882
July 1st.	10	6	3,800	4	1,470	2nd half	83,279
Jan'y 1st., 1887	12	9	5,000	3	970	1st. half	83,786
July 1st.	12	9	4,600	3	1,370	2nd half	92,616
Jan'y 1st., 1888	12	10	5,150	2	820	1st. half	111,433
July 1st.	18	7	3,600	11	6,570	2nd half	204,898
Jan'y 1st., 1889	20	16	9,400	4	1,770	1st half	281,415
July 1st.	32	20	11,735	12	6,545	2nd half	326,915
Jan'y 1st., 1890	35	23	13,814	12	7,314	1st half	375,389
July 1st.	36	26	15,494	12	7,397	2nd half	343,107
Jan'y 1st., 1891	37	12	8,047	25	15,295	1st. half	302,776
July 1st.	38	22	14,462	16	10,272	2nd half	414,911
Jan'y 1st., 1892	38	25	17,245	13	7,993	1st half	433,358
July 1st.	38	24	15,927	14	8,826	2nd half	402,482
Jan'y 1st,, 1893	38	21	15,794	17	9,798	1st. half	403,447
July 1st.	38	17	12,669	21	12,947	2nd half	256,278
Jan'y 1st., 1894	38	11	10,908	27	17,345	1st half	236,396
July 1st.	38	8	7,630	30	20,305	2nd half	319,918
Jan'y 1st., 1895	38	15	14,911	23	14,240	1st half	387,793
July 1st.	38	17	17,142	20	12,885	2nd. half	448,058
Jan'y 1st., 1896	39	19	19,005	20	12,555	1st. half	448,006
July 1st.	39	17	18,936	22	13,428	2nd half	444,377

TABLE XVIII.—*Continued.*

Condition, Weekly Capacity and Production of Coke Iron Furnaces in Alabama, 1882-1910—*Continued.*
Tons of 2240 *pounds.*

Year.	Total.	In.	Weekly capacity, tons.	Out.	Weekly capacity, tons.	Production: tons.	
Jan'y 1st., 1897	39	15	17,471	24	15,052	1st half	429,742
July 1st.	39	15	16,837	24	16,913	2nd half	503,176
Jan'y 1st., 1898	39	18	20,009	21	12,640	1st half	493,609
July 1st.	39	18	17,709	21	13,665	2nd half	503,333
Jan'y 1st., 1899	38	18	18,563	20	12,427	1st half	502,483
July 1st.	37	22	21,876	15	8,585	2nd. half	539,753
Jan'y 1st., 1900	37	19	17,718	18	11,835	1st half	575,947
July 1st.	37	21	17,069	16	11,419	2nd half	550,758
Jan'y 1st., 1901	38	25	23,176	13	8,918	1st half	602,206
July 1st.	38	24	22,450	14	10,175	2nd half	569,996
Jan'y 1st., 1902	39	26	25,459	13	9,475	1st half	677,199
July 1st.	40	27	24,614	13	10,240	2nd half	734,478
Jan'y 1st., 1903	40	33	31,900	7	4,615	1st half	741,271
July 1st.	39	28	27,029	11	9,339	2nd half	747,020
Jan'y 1st., 1904	40	28	28,732	12	10,030	1st half	780,422
July 1st.	41	24	27,106	17	15,990	2nd half	642,599
Jan'y 1st., 1905	42	22	24,687	20	19,295	1st half	729,847
July 1st.	44	27	29,828	17	15,730	2nd half	848,669
Jan'y 1st., 1906	43	29	33,944	14	14,253	1st. half	814,440
*July 1st.	43	24	------	19	------	2nd. half	834,578
Jan'y 1st., 1907	41	30	------	11	------	1st half	846,034
July 1st.	44	31	------	13	------	2nd half	805,499
Jan'y 1st., 1908	44	13	------	31	------	1st half	596,280
July 1st.	46	19	------	27	------	2nd half	776,919
Jan'y 1st., 1909	46	23	------	23	------	1st half	784,712
July 1st.	46	17	------	29	------	2nd half	945,264
Jan'y 1st., 1910	46	27	------	19	------	1st half	997,206
July 1st.	46	23	------	23	------	2nd half	906,237

*** The figures for these tables from July 1, 1906 to July 1, 1910 inclusive have been furnished by Mr. James M. Swank in personal letters.—E. A. S.**

According to the Directory of the American Iron and steel Association there were 36 completed stacks in Alabama in 1894. They were of the following character:

Size, Feet	Number of Stacks.
60x12	1
65x13 2/3	1
65x14	4
65x16	1
65x16½	1
70x15	1
72x18	1
75x15	2
75x16	2
75x17	14
75x18	4
80x20	4
	36

There were four furnaces of a height of 80 feet, and upwards. The capacity of all of the furnaces, January 1, running full time was 1,469,156 tons of pig iron. The actual production, during the year was 556,314 tons, or 37.8 per cent. of the capacity.

In 1904, ten years later, there were 43 completed stacks of the following character:

Size, Feet	Number of Stacks.
60x12	1
65x14¾	1
72x18	1
73x17	2
73x18	1
75x15	1
75x15¾	1
75x16	2
75x17	12
75x17 1/6	1
75x18	5
80x17½	1
80x18	1
80x20	4
82x20	1
82½x18	1
85x18	1
85x19	1
86x19	1
90x18½	3
90x20	1
	43

There were 15 furnaces of a height of 80 feet and above. The capacity of all of the furnaces on the 1st of January, running full time, was 2,015,624 tons. The actual production during the year was 1,423,021 tons, or 70.6 per cent. of the capacity.

In 1910 the total number of completed stacks was 45, as follows:

Size, Feet	Number of stacks.
60x12	1
65x14¾	1
70x17 1/6	1
72x18	1
73x17	2
73x18	2
75x15	1
75x16	3
75x17	9
75x18	3
75x19	1
76½x15½	1
78x18	1
80x17.9	1
80x18	1
82½x18	1
84¼x21¾	1
85x18	1
85x19½	1
85x20	3
86x19	1
86′ 7″x20′ 9″	2
90x18	2
90x20	1
90x22½	1
91 1/3x22′ 10″	1
92¼x22½	1
	45

There were 18 stacks of 80 feet and above and 6 stacks of 90 feet and above.

The capacity of all of the furnaces, running full time, on the 1st of January, 1910, was 3,334,750 tons and the production, during the year, was 1,903,443 tons, or 57.1 per cent. of the capacity at the first of the year.

The United States Steel Corporation, through the Tennessee Coal, Iron & Ry. Co., owns 14 stacks out of the 45, or 31.1 per cent. of the total number of completed stacks. Its annual capacity in pig iron is 1,164,000 tons out of a total ca-

pacity for the State at large of 3,334,750 tons, or 34.9 per cent.

The six large stacks of this corporation, at Ensley, have a capacity of 768,000 tons of pig iron annually.

Of recent years the manifest tendency is towards the construction of larger furnaces, for in 1910 there were 18 stacks in the State of a height of 80 feet and above, as against 15 of such furnaces in 1904 and 4 in 1894.

The number of stacks and the annual capacity in tons of pig iron of the several companies is as follows:

Company—	Stacks	Capacity per annum, Tons.
Alabama Consolidated Coal & Iron Co.	4	280,000
Anniston Iron Corporation	2	120,000
Birmingham Coal & Iron Co.	2	144,000
Central Iron & Coal Co.	1	60,000
Jenifer Furnace Co.	1	50,000
Lookout Mountain Iron Co.	1	100,000
Northern Alabama Coal, Iron & Ry. Co.	1	40,000
Republic Iron & Steel Co.	3	270,000
Sheffield Coal & Iron Co.	3	210,000
Sloss-Sheffield Steel & Iron Co.	7	435,000
Southern Iron & Steel Co.	2	168,000
Tennessee Coal, Iron & Ry. Co.	14	1,164,000
Williamson Iron Co.	1	30,000
Woodward Iron Co.	3	263,750
Total	45	3,334,750

COKE FURNACE PRACTICE.

The period immediately preceding 1904 was characterized by the erection of larger furnaces, whether new furnaces or old ones re-modeled. There has been no material change in the situation during the last few years, so that the figures for 1904 are still applicable. The tendency has been strongly towards larger furnaces and this means larger and heavier blowing-engines and, perhaps, more rapid driving. In the second edition, of this work, 1898, the writer gave a detailed discussion of coke furnace practice, in so far as it related to consumption of raw materials. The Tables there given are re-produced here, with some modifications. They embody results obtained between the years 1890 and 1896. With the exception of the differences in the cost of raw material and la-

bor, which, of course, are most important, present practice does not vary much from that of ten years ago. Through the kindness of furnace managers these Tables have, in a measure, been brought down to date. There will be given, first, the Tables that appeared in the former edition, with the discussion that followed, and then the more recent Tables, with a discussion of the results.

TABLE XIX.—*Illustrative of Coke Furnace Practice with Hard (Limy) and Soft Red Ore. Increasing percentage of Hard Ore, from 48.2 to 100. Tons of 2240 pounds.*

Year.	No. of charges	Per ct. of Ore Burden		Per ct. of Total Burden.				Iron Made:			Consumption: Tons per ton of Iron.			
		Hd. Ore.	Soft Ore	Hd. Ore.	Soft Ore	Stone.	Coke.	Per Chg	Total.	% F.Grd.	Ore.	Stone.	Coke.	Total.
1895	2,872	48.2	51.8	24.0	26.3	17.2	32.5	1.45	4,157	83.9	2.26	0.79	1.57	4.62
1895	2,708	50.9	49.1	27.0	26.1	15.6	31.3	1.54	4,155	68.3	2.54	0.77	1.47	4.78
1895	2,870	50.9	49.1	28.1	27.1	15.8	29.0	1.72	4,943	96.2	2.51	0.72	1.32	4.55
1895	2,954	50.9	49.1	27.7	26.7	15.5	30.1	1.66	4,912	99.2	2.39	0.68	1.34	4.41
1895	2,742	51.1	48.9	26.5	25.3	15.8	32.4	1.47	4,037	88.6	2.42	0.73	1.52	4.67
1895	3,029	52.3	47.7	27.2	24.8	16.0	32.0	1.62	4,932	90.2	2.27	0.69	1.39	4.35
1895	3,003	52.3	47.7	26.2	24.1	16.6	33.1	1.49	4,495	87.0	2.32	0.73	1.52	4.57
1890	1,508	65.9	34.1	36.6	19.0	10.3	34.1	1.97	2,970	95.7	2.48	0.45	1.52	4.45
1890	1,343	65.9	34.1	36.4	18.7	10.0	34.9	1.95	2,615	87.8	2.51	0.46	1.60	4.57
1890	1,512	65.9	34.1	36.9	19.1	9.7	34.3	1.92	2,898	93.2	2.57	0.44	1.58	4.59
1893	1,805	80.7	19.3	47.4	11.2	5.7	35.7	1.83	3,315	93.8	2.68	0.26	1.63	4.57
1893	1,995	91.5	8.5	57.3	5.2	2.3	35.2	1.96	3,901	83.9	2.78	0.10	1.56	4.44
1893	1,576	100.	---	63.8	---	---	36.2	1.91	3,005	59.4	2.87	---	1.63	4.50

This table is based on 29,917 charges representing 50,335 tons of pig iron.

From 1890 to 1895 the average number of tons of material handled, per ton of pig iron made, was about 4.44. The amount of ore required to make a ton of iron varied from 2.10 to 2.87 tons. the average being close to 2.50 tons. The average amount of coke used was 1.41 tons of 2240 lbs., the range being from 1.16 to 1.60 tons.
tle hard (limy) ore was used.

The average amount of stone used was about 0.53 ton, the range being from 0.10 to 0.88 ton, according as much or little hard (limy) ore was used.

Table No. XIX gives the results of observations based on the production of 50,335 tons of pig iron when using burdens composed of hard and soft red ore, in the years 1890, 1893 and 1895.

An examination of this Table will show:

1.—The amount of ore used per ton of iron made increases with the percentage of hard ore in the burden, rising from 2.39 tons with 61 per cent. to 2.52 tons with 66 per cent. and 2.78 tons with 90 per cent. This means, of course, that the hard ore contains less iron than the soft ore.

2.—The amount of limestone used per ton of iron made decreases with the increase of hard ore, falling from 0.69 ton with 51 per cent. to 0.45 ton with 66 per cent. and 0.12 ton with 90 per cent. With 50 per cent. of hard ore in the burden the consumption of stone was 1545 lbs. per ton of iron made, with 66 per cent. of hard ore it was 1008 lbs. and with 90 per cent. it was 269 lbs. In one furnace for a period of three months the consumption of stone per ton of iron made was 0.75 ton. As the hard ore carries its own lime it is easy to see why the proportion of stone decreases with the increase of hard ore in the burden.

3.—The amount of coke used per ton of iron increases with the increase in hard ore, rising from 1.34 tons with 51 per cent. to 1.57 tons, with 66 per cent. and 1.61 tons with 90 per cent. In the case of one furnace carrying 50.6 per cent. of hard ore the consumption of coke per ton of iron made during a period of three months was 1.52 tons of 2240 lbs., or 1.52 lbs. per pound of iron made.

Coke is always the most costly ingredient of the burden. In this table the cost of the coke does not fall below 53 per cent. of the total raw material cost. The marked tendency towards increased coke consumption with increasing proportions of hard ore leads to increased cost of production, in so far as concerns the raw materials.

The consumption of coke per ton of iron, the quality of the coke, ore and stone being the same, depends to a great extent upon the manner in which the furnace is run, its equipment, etc. Instances are on record in Alabama where the consumption of coke per ton of iron, with very heavy hard ore burdens, over a considerable period did not exceed 1.25 tons (2800 lbs.), but the general furnace equipment was good.

One of the best blast furnace managers in the Birmingham district has said that he could use all hard ore (of the best self-fluxing type) and make iron with 1.25 tons of coke, without impairing the quality of the iron.

The use of crushed hard ore tends to diminish the consumption of coke, for hard ore in lumps is not easily penetrated by the reducing gases. When a large lump, weighing from 50 to 75 lbs., is exposed to the heat of the furnace the outside is first affected. The carbonic acid of the carbonate of lime is driven off, the oxide of iron begins to part with its oxygen and processes of disintegration are set up which continue until the ore is broken into small fragments.

The oxide of iron is not completely reduced until each piece is exposed to the de-oxidizing gases. This takes place with comparative rapidity if the ore is porous, as with certain kinds of brown ore, or if the fragments of ore are sufficiently small. These fragments must not, however, be too small, else the current of gas is checked and diverted from its regular course, the burden packs and the furnace "hangs." But if the size of the ore particles is such as to allow of easy gas-penetration while not so small as to cause irregularities in the descent of the burden, we have favorable conditions for reduction. The hard, or limy, ore has a double advantage over the soft ore, for it generally contains enough lime to flux its own silica and in addition carries the lime as carbonate. When this carbonate of lime is exposed to the heat of the furnace its carbonic acid is set free and the ore begins to crumble. The porosity of the ore is increased up to a certain point, but beyond this the crumbling of the ore may be of no advantage and is not if it proceeds too rapidly.

The great advantage in the use of hard ore is the saving in extraneous lime. Using 80 per cent. of hard ore and 20 per cent. of soft ore there are required 582 lbs. of limestone as against 1680 lbs. for 50 per cent. hard and 50 per cent. soft ore. This saving, however, may be more than counterbalanced by the greater amount of ore and coke required, for in the case of heavy hard ore burdens we have a much larger quantity of material to fuse. This would not be true if all of the hard ore was really self-fluxing.

4.—The tendency of the percentage of foundry grades of pig iron is towards a decrease with the increase of hard ore.

While this is not strongly accentuated yet the evidence is too pronounced to be altogether neglected.

Individual cases may be cited wherein the percentage production of foundry grades during a month was higher when the proportion of hard ore rose to 80 per cent. than when it was 52 per cent. There are other cases, however, in which the tendency towards the lower foundry grades asserts itself when the proportion of hard ore increases. But this is a matter so closely connected with furnace practice, the regulation of the heat, the rapidity of driving, etc., that no definite rule may be established. During the last few years, when there has been a steady increase in the proportion of hard ore used, there does not appear to have been any serious falling off in the quality of the iron.

The influences of increasing amounts of hard ore on the quality of the iron is of the utmost importance. The higher the percentage yield of foundry grades the more valuable is the product. Anything, therefore, that tends to interfere with the make of foundry iron should be most carefully investigated and conclusions drawn from authentic records must be the sole ground for argument.

The writer has personally investigated thirteen cases, the charges being 32,917 and the amount of iron represented 50,-360 tons.

There were two cases in which the percentage of hard ore in the ore burden was 50.9 and one case in which the percentage was 52.3. On these burdens the percentage of foundry grades was 99.2, 96.2 and 90.2, the average being 95.2. The total number of charges was 8,853 and the make or iron 14,-798 tons.

There were four cases in which the percentage of hard ore in the ore burden was 48.2, 50.9, 51 1 and 52.3 The percentage of foundry grades was 83.9, 68.3, 88.6 and 87.0, respectively, the average being 81.9. The number of charges was 11,325 and the make of iron was 16,845 tons.

In these cases the average percentage of hard ore in the ore burden was 50.6 as against 51.3 per cent. in the first cases, while the average percentage of foundry grades was 81.9 as against 95.2. While there was a small difference in respect to the amount of hard ore used there was a marked difference in the percentage of foundry grades made.

Three cases were examined in which the percentage of hard ore in the ore burden was 65.9. From one of them, with 1,508 charges and 2,070 tons of iron the percentage of foundry grades was 95.7. From another with 1,343 charges and 2.615 tons of iron, the percentage of foundry grades was 87.8. From the third, with 1,512 charges and 2,898 tons of iron, the percentage of foundry grades was 93.2. The average of 4,363 charges and 8,483 tons of iron was 92.2 per cent. of foundry grades.

Finally, three cases were examined in which the percentage of hard ore in the ore burden rose from 80.7 to 100. From one of these with 80.7 per cent. of hard ore, there was a yield of 93.8 per cent. in foundry grades, the number of charges being 1,805 and the make of iron 3,315 tons. From another, with 91.5 per cent. of hard ore there was a yield of 83.9 per cent. in foundry grades, the number of charges being 1,995 and the make of iron 3,901 tons. From the third case, with 100 per cent. of hard ore in the ore burden, there was a yield of 59.4 per cent. in foundry grades, the number of charges being 1,576 and the make of iron 3,005 tons.

Averaging the results from two furnaces carrying about 50 per cent. of hard ore in the ore burden we find that with 20,178 charges and 31,643 tons of iron the percentage of foundry grades was 88.5.

Comparing this with the results from the furnace carrying 65.9 per cent. of hard ore, with 4,363 charges, 8,483 tons of iron and 92.2 per cent. of foundry grades, there would seem to be an avantage of 3.7 per cent. of foundry grades for the higher percentage of hard ore. Taking these together and comparing with them the results from the burden averaging 90 per cent. of hard ore there is found to be a decided falling off in the percentage of foundry grades.

Perhaps all that may be said now is that there seems to be a tendency towards inferior grades of iron when the percentage of hard ore in the ore burden is above 66. The smaller the yield of iron from the furnace the higher is the percentage of foundry grades and this seems to be independent of the amount of hard ore carried in the burden. Out of 8 cases in which the monthly yield was between 3,900 and 5,000 tons there were more than one-third in which the yield of foundry grades fell below 87 per cent. Out of five cases in which the

monthly yield was between 2.500 and 3,500 tons there was one case, or 20 per cent., in which the percentage of foundry grades fell below 87.

Whether we may conclude that rapid driving on a hard ore burden tends to lower the grade of iron is not quite clear. Provided that the furnace has sufficient engine power and stoves there is no reason why it should not work off on foundry grades, even with a very heavy hard ore burden. The failures may have been due to improper handling of the furnace.

In Table XIX, the total amount of coke used in making the 50,335 tons of iron was 75,079 tons, or a consumption of 3,337 lbs. of coke per ton of iron. The largest consumption was 3,651 lbs. and the smallest 2.956 lbs. On the average and with different percentages of hard ore in the burden the consumption of coke should not exceed 3300 lbs. per ton of iron. On the average and with increasing amounts of hard ore in the burden the consumption of coke is about 300 lbs. more. per ton of iron than when using increasing percentages of brown ore in a mixed burden.

TABLE XX.—*Illustrative of Coke Furnace Practice with Hard (Limy) and Soft Red Ore. Increasing percentage of Hard Ore, from 70 to 98. Tons of 2240 lbs.*

Year.	No. of charges	% of ore Burden.		Per cent of Total Burden.				Iron Made: Tons.			Consumption: Tons per ton of Iron.				
		Hd. Ore.	Sft. Ore.	Hd. Ore.	Sft. Ore.	Stone.	Coke.	Per Chg.	Total.	% F.Grd.	Hd. Ore.	Sft. Ore.	Stone.	Coke.	Total.
1907	3,397	70	30	36	16	11	37	1.73	5,876	*	1.72	0.76	0.54	1.78	4.80
1907	3,092	80	20	41	10	14	35	1.71	5,291	*	2.01	0.49	0.68	1.70	4.88
1907	3,384	87	13	50	7	10	33	1.40	4,747	99	2.35	0.33	0.47	1.58	4.73
1907	3,729	98	2	58	1	6	35	1.53	5,715	99	2.53	0.60	0.29	1.51	4.39

* Basic.

Table XX is based on 13,602 charges, representing 21,629 tons of iron, of which 11,167 tons were basic iron intended for steel making and 10,462 tons were of foundry grades. The consumption of coke decreases as the proportion of hard ore

increases, being 1.78 tons with 70 per cent of hard ore and 1.51 tons with 98 per cent of hard ore. In this case the admixture of soft red ore with hard red ore has a marked tendency to increase the consumption of coke per ton of iron, and this is true both of basic iron and foundry iron. In order to compare these results, obtained in 1907, with results of the practice that was current in the years 1890-1893 the following table has been constructed from Table XIX.

The comparison is made with burdens as nearly similar as possible, identical burdens not having been recorded.

TABLE XXI.—*Illustrative of Coke Furnace Practice with Hard (Limy) and Soft Red Ore, the percentage of Hard Ore Increasing from 65.9 to 100. Tons of 2240 pounds.*

Year.	No. of charges.	Per ct. of Ore Burden.		Per ct. of Total Burden.				Iron Made:			Consumption: Tons per ton of Iron.			
		Hd. Ore.	Sft. Ore.	Hd. Ore.	Sft. Ore.	Stone.	Coke.	Per Chg.	Total.	% F.Grd.	Ore.	Stone.	Coke.	Total.
1890	1,508	65.9	34.1	36.6	19.0	10.3	34.1	1.97	2,970	95.7	2.48	0.45	1.52	4.45
1890	1,343	65.9	34.1	36.4	18.7	10.0	34.9	1.95	2,615	87.8	2.51	0.46	1.60	4.57
1890	1,512	65.9	34.1	36.9	19.1	9.7	34.3	1.92	2,898	93.2	2.57	0.44	1.58	4.59
1893	1,805	80.7	19.3	47.4	11.2	5.7	35.7	1.83	3,315	93.8	2.68	0.26	1.63	4.57
1893	1,995	91.5	8.5	57.3	5.2	2.3	35.2	1.96	3,901	83.9	2.78	0.10	1.56	4.44
1893	1,576	100.	---	63.8	---	---	36.2	1.91	3,005	59.4	2.87	---	1.63	4.50

Table XXI is based on 9,739 charges representing 18,704 tons of iron, the percentage of foundry grades varying from 95.7, with 65.9 per cent. of hard ore in the ore burden, to 59.4 with 100 per cent. In this case and under the conditions that maintained between 1890 and 1893 there is observed an increase of coke, per ton of iron made with the increase in the proportion of hard ore. When the percentage of hard ore in the ore burden was 65.9 the consumption of coke, per ton of iron was 1.52 tons (3404.8 pounds) and this rose to 1.63 tons (3651.2 pounds) when the ore burden was composed entirely of hard ore. This shows an increase of coke of 246.4 pounds, per ton of iron, as between these two burdens. When the percentage of hard ore was 80.7 the consumption of coke was 1.63

tons, or the same as for a burden of 100 per cent. of hard ore. During 1907, as by Table XX, the consumption of coke, per ton of iron was 1.70 tons (3808 pounds) when the hard ore comprised 80 per cent. of the ore burden. That is, the current consumption of coke on practically the same burden, was 157 pounds more per ton of iron than it was in 1893. In 1893 the 3651 pounds of coke had to melt 2.94 tons (6585.6 pounds) of material, excluding its own ash. In 1907 the 3808 pounds of coke had to melt 3.18 tons (7123.2 pounds) of material, excluding its own ash. In both these cases the stone is considered as material to be melted. In 1893 one pound of coke melted 1.81 pounds of stock and in 1907 one pound of coke melted 1.87 pounds of stock. There is a close agreement between these results, showing that the practice in 1893, in so far as concerns coke consumption, was about as good as it is now. These returns are from the same establishment and relate to ore burdens carrying about 80 per cent. of hard and about 20 per cent. of soft red ore.

With ore burdens of 98 to 100 per cent. of hard ore the case is somewhat different. In 1893, when the hard ore comprised 100 per cent. of the ore burden, the consumption of coke, per ton of iron, was 1.63 tons (3651.2 pounds), one pound of coke melting 1.77 pounds of stock. In 1907, when the hard ore comprised 98 per cent of the ore burden, the consumption of coke, per ton of iron, was 1.51 tons (3382.4 pounds) and one pound of coke melted 2.21 pounds of stock.

With the higher hard ore burden current practice is considerably better than the practice fourteen years ago. This is a distinctly encouraging feature, for unless there should be a large augmentation of the supply of brown ore which does not seem to be imminent, we are likely to see ore burdens of considerably more than 80 per cent. of hard ore. To know that a pound of iron can be produced here on very high hard ore burdens with 1½ pounds of coke is decidedly favorable to the stability of the iron industry, for it is upon such burdens that the chief dependence must be placed, so far as present indications are concerned. Of course, if there should be a notable extension of brown ore mining, furnace practice would conform to the changed conditions, but there does not now seem to be any immediate probability of this, however desirable it may be.

TABLE XXII.—*Illustrative of Coke Furnace Practice with Hard (Limy) and Soft Red Ore and Brown Ore. The percentage of Brown Ore being 17. Tons of 2240 lbs.*

Year.	No. of charges.	Per ct. of Ore Burden.			Per ct. of Total Burden.					Iron Made:			Consumption: Tons per ton of Iron.					
		Hd. Ore.	Sft. Ore.	Brn. Ore	Hd. Ore.	Sft. Ore.	Brn. Ore	Stone.	Coke.	Per Chg.	Total.	% F.Grd.	Hd. Ore.	Sft. Ore.	Brn. Ore	Stone.	Coke.	Total.
1907	3,032	67	16	17	35	9	11	12	33	1.89	5,735	*	1.59	0.42	0.48	0.53	1.42	4.44

* Basic.

TABLE XXIII.—*Illustrative of Coke Furnace Practice with Hard (Limy) and Brown Ore, the percentage of Brown Ore increasing from 12.5 to 34 of the ore burden. Tons of 2240 pounds.*

Year.	No. of charges.	Per ct. of Ore Burden.		Per ct. of Total Burd				Iron Made:			Consumption: Tons per ton of Iron.				
		Hd. Ore.	Brn. Ore	Hd. Ore.	Brn. Ore	Stone.	Coke.	Per Chg.	Total.	% F.Grd.	Hd. Ore.	Brn. Ore.	Stone.	Coke.	Total.
1907	2,225	87.5	12.5	49	10	9	31	3.4	7,633	85	2.10	0.45	0.28	1.33	4.16
1907	2,287	75	25	43	19	8	30	4.2	9,204	*	1.81	0.79	0.32	1.27	4.19
1905	2,215	66	34	41	21	9	29	5.2	11,544	*	1.55	0.77	0.31	1.07	3.70

* Basic.

Ore burdens composed of Hard (Limy) and Soft Red Ore and Brown Ore, the proportion of brown ore rising from 1.3 per cent. to 100 per cent.

TABLE XXIV.—*Illustrative of Coke Furnace Practice with Hard (Limy) and Soft Red Ore and Brown Ore. Increasing percentage of Brown Ore, from 1.3 to 100. Tons of 2240 lbs.*

Year.	No. of charges.	Per ct. of Ore Burden.			Per ct. of Total Burden.					Iron Made:			Consumption: Tons per ton of Iron.			
		Hd. Ore.	Sft. Ore.	Brn. Ore	Hd. Ore.	Sft. Ore.	Brn. Ore	Stone.	Coke.	Per Chg.	Total.	% F.Grd.	Ore.	Stone.	Coke.	Total.
1894	2,687	33.4	65.3	1.3	17.0	33.1	0.6	16.9	32.4	1.69	4,568	95.8	2.22	0.73	1.44	4.39
1895	2,945	47.1	51.5	1.4	24.4	26.7	0.6	16.8	31.5	1.57	4,635	97.9	2.37	0.75	1.45	4.57
1894	2,690	48.5	50.0	1.5	26.5	27.3	0.7	15.9	29.6	1.79	4,818	99.7	2.29	0.64	1.24	4.17
1895	2,962	46.6	50.0	3.4	23.2	24.9	1.6	18.7	31.6	1.69	5,002	97.6	2.11	0.78	1.34	4.23
1895	2,957	48.4	46.8	4.8	25.1	24.3	2.5	16.6	33.5	1.65	4,886	99.5	2.23	0.72	1.37	4.32
1895	2,833	42.4	50.8	6.8	22.1	26.5	3.7	17.1	30.6	1.64	4,659	99.2	2.35	0.77	1.38	4.50
1895	2,847	42.1	50.7	7.2	21.8	26.3	3.7	17.6	30.6	1.63	4,678	94.5	2.34	0.78	1.38	4.50
1890	1,635	57.1	42.5	10.4	31.9	23.8	0.3	10.6	33.4	2.01	3,291	83.1	2.48	0.47	1.48	4.43
1890	1,819	53.7	34.2	12.1	28.5	18.2	6.3	10.6	36.4	1.88	3,418	92.0	2.51	0.49	1.72	4.72
1890	1,712	70.3	9.3	20.4	40.0	5.2	11.6	6.4	36.8	1.88	3,209	86.9	2.55	0.29	1.61	4.45
1890	1,609	58.5	20.4	21.1	32.3	11.2	11.7	8.4	36.4	1.89	3,011	90.0	2.50	0.44	1.52	4.49
1890	1,994	53.7	19.2	27.1	29.9	10.7	15.1	9.7	34.6	2.01	3,990	89.2	2.40	0.41	1.49	4.30
1895	1,904	17.3	35.1	47.6	8.9	18.2	24.6	19.2	29.1	1.34	2,569	92.8	2.37	0.88	1.32	4.57
1894	1,900	18.3	33.3	48.4	10.0	17.6	25.3	18.6	28.5	1.29	2,456	99.9	2.45	0.87	1.35	4.68
1895	1,983	21.0	28.1	50.9	10.5	14.0	25.3	20.0	30.2	1.37	2,708	99.2	2.16	0.86	1.31	4.33
1895	1,909	23.8	24.8	51.4	12.4	13.0	26.8	18.2	29.6	1.23	2,369	92.1	2.50	0.87	1.41	4.78
1895	2,076	16.0	17.7	66.3	8.8	9.8	36.7	18.1	26.6	1.37	2,844	98.1	2.68	0.88	1.28	4.84
1895	1,802	----	----	100.0	----	----	52.9	20.4	26.7	1.53	2,766	99.1	2.31	0.89	1.16	4.36

This table is based on 40,270 charges representing 66,653 tons of pig iron.

An examination of Table XXIV will show:

1.—The amount of brown ore used per ton of iron made varied from 2.11 to 2.68 tons, i. e., the brown ore contained from 47.4 to 37.3 per cent. of metallic iron, as charged. When using the richer iron the number of charges was 2,962 and the iron made was 5,002 tons, of which 97.6 per cent. was of foundry grades. The ore burden was composed of 46.6 per cent. of hard ore, 50.0 per cent of soft ore and 3.4 per cent. of brown ore.

The total burden was composed as follows:

	Per cent.
Hard ore	23.2
Soft ore	24.9
Brown ore	1.6
Limestone	18.7
Coke	31.6
	100.0

The consumption of materials per ton of iron was:

	Tons.
Ore	2.11
Stone	0.78
Coke	1.34
	4.23

All of 2,240 lbs.

When the amount of brown ore was doubled, becoming 6.8 per cent. of the ore burden, with 42.4 per cent of hard ore and 50.8 per cent. of soft ore, the number of charges was 2,833 and the make of iron 4,659 tons, of which 99.2 per cent. was of foundry grades. In this case the composition of the total burden was as follow'

	Per cent.
Hard ore	22.1
Soft ore	26.5
Brown ore	3.7
Limestone	17.1
Coke	30.6
	100.0

The consumption of materials per ton of iron was:

	Tons of 2,240 lbs.
Ore	2.35
Stone	0.77
Coke	1.38
	4.50

The amount of brown ore was raised to 12.1 per cent. in the ore burden, with 53.7 per cent. of hard and 34.2 per cent. of soft ore. The number of charges was 1819 and the make of iron 3,418 tons, of which 92.0 per cent. was of foundry grades. The composition of the entire burden was:

	Per cent.
Hard ore	28.5
Soft ore	18.2
Brown ore	6.3
Limestone	10.6
Coke	36.4
	100.0

The consumption of materials per ton of iron was:

	Tons of 2,240 lbs.
Ore	2.51
Stone	0.49
Coke	1.72
	4.72

This was the highest consumption of coke noted.

The amount of brown ore was raised to 27.1 per cent. in the ore burden, with 53.7 per cent. of hard ore and 19.2 per cent. of soft ore. The number of charges was 1,994 and the make of iron 3,990 tons, of which 89.2 per cent. was of foundry grades. The composition of the entire burden was:

	Per cent.
Hard ore	29.9
Soft ore	10.7
Brown ore	15.1
Limestone	9.7
Coke	34.6
	100.0

The consumption of materials per ton of iron was:

	Tons of 2,240 lbs.
Ore	2.40
Stone	0.41
Coke	1.49
	4.30

The amount of brown ore in the ore burden was raised to 50.9 per cent, with 21.0 per cent. of hard and 28.1 per cent. of soft ore. The number of charges was 1,983 and the make of iron 2,708 tons, of which 99,2 per cent. was of foundry grades. The composition of the entire burden was:

	Per cent.
Hard ore	10.5
Soft ore	14.0
Brown ore	25.3
Limestone	20.0
Coke	30.2
	100.0

The consumption of materials per ton of iron was:

	Tons of 2,240 lbs.
Ore	2.16
Stone	0.86
Coke	1.31
	4.33

The amount of brown ore was raised to 66.3 per cent. of the ore burden, with 16.0 per cent. of hard and 17.7 per cent. of soft ore. The number of charges was 2,076 and the make of iron 2,844 tons, of which 98.1 per cent. was of foundry grades. The composition of the entire burden was:

	Per cent.
Hard ore	8.8
Soft ore	9.8
Brown ore	36.7
Limestone	18.1
Coke	26.6
	100.0

The consumption of materials per ton of iron was:

	Tons of 2,240 lbs.
Ore	2.68
Stone	0.88
Coke	1.28
	4.84

Finally, the amount of brown ore in the ore burden was raised to 100 per cent. The number of charges was 1,802 and the make of iron 2,766 tons, of which 99.1 per cent. was of foundry grades.

The composition of the entire burden was:

	Per cent.
Brown ore	52.9
Limestone	20.4
Coke	26.7
	100.0

The consumption of materials per ton of iron was:

	Tons of 2,240 lbs.
Ore	2.31
Stone	0.89
Coke	1.16
	4.36

This was the lowest consumption of coke noted. In Table No. XXIII, the consumption of coke per ton of iron varies from 1.16 tons of 2,240 lbs to 1.72 tons, or from 2,598 to 3,852 lbs. for 2,240 lbs. of iron. At the present time the consumption of 2.598 lbs. of coke per ton of iron would be considered very good practice. The total amount of coke used in making the 66,653 tons of iron represented by Table No. XXIII, was 91,035 tons, or a consumption of 3,059 lbs. of coke per ton of iron. The largest consumption of coke was 3,852 lbs. per ton of iron and the smallest was 2,598 lbs. per ton of iron. On the average and with different percentages of brown ore in the burden the consumption of coke should not exceed 3,000 lbs. per ton of iron. Under exceptionally good practice it would be less than this and would range around 2,600 lbs.

2.—The amount of limestone used per ton of iron varies with the amount of hard ore used, being 0.42 ton with 58 per cent. of hard ore, 0.74 ton with 44 per cent. and 0.87 ton with 16 per cent. We may compare these results with those from an ore burden of hard and soft red ore. With 48 per cent. of hard ore in such a burden the consumption of stone was 0.79 ton. With 65.9 per cent. of hard ore the consumption of stone was 0.45 ton per ton of iron. The hard ore burden with 100 per cent. of hard ore required no stone, but the burden with 100 per cent. of brown ore required 0.87 ton of stone per ton of iron.

3.—The amount of coke used per ton of iron decreases with the increase of brown ore, except in the case of a furnace using 58.6 per cent. of hard ore. The general tendency of hard ore burdens is to increase the amount of coke required per ton of iron and the general tendency of brown ore burdens is to decrease the amount of coke per ton of iron. With from 27 to 100 per cent. of brown ore in the ore burden the consumption of coke per ton of iron varies from 3,337 lbs. to 2,598 lbs., the average being 3,001 lbs., the amount of iron represented being 19,702 tons. With any ordinary burden, therefore, carrying more than 27 per cent. of brown ore, the remainder being hard and soft red ore, the consumption of coke per ton of iron should not exceed 3,000 lbs.

4.—The tendency of increasing the proportion of hard ore, in burdens composed of hard and soft red ore and brown ore, is towards a decrease in the percentage of foundry grades. But this tendency is not always manifested and may be due to other considerations.

As might be expected from the more complex nature of the burden the admixture of hard, soft and brown ores occasions greater variations in the economies of production than burdens of hard and soft ore or of brown ore alone. We suspect that these variations are traceable more to the fluctuations in the quality of the brown ore than to any other single circumstance. The condition in which brown ore from the same mine and washery reaches the stock-house has to be observed personally before one can fully appreciate what these fluctuations are. When the brown ore "bank" is in fairly good ore, the clay easily disintegrated and removed and the chert picked out the ore will come in clean. When the clay is

"tough," the ore cherty and the water scanty the ore will come in with entirely too much clay and chert.

This brings us back to the previous question of properly preparing brown ore. There are not many deposits which will provide material to be improved simply by a washing process. In by far the greater number of brown ore "banks" the washing must be supplemented by crushing and jigging if the best quality of ore is to be shipped. This matter has not received the attention its importance demands. Alabama brown ore miners have for too long a time contented themselves with installing the ordinary log-washers, trusting to the persistent demand for brown ore to over-look the fact that the ore is not as good as it should be.

The furnaces are in no condition to insist too rigorously upon quality, they must use what can be secured, thanking a merciful Providence for what they can get. With proper washing, crushing and jigging, supplemented by a thorough calcination, there is no reason why the minimum content of iron in brown ore should be below 50 per cent. It is certainly a good deal below this now.

We must have brown ore and we must have the best. The mililon tons of brown ore used should contain not less than 500,000 tons of iron, worth $10,000,000 instead of 430,000 tons worth $8,600,000. There is a difference here of $1,400,000 in favor of the better ore. When to this is added the saving in coke and the increased production of better grades of iron the difference may well be $2,500,000 to $3,000,000.

Too much care can not be given to the materials going into the furnace, care bestowed not only upon the percentage of iron but also and particularly upon uniformity of composition. The lack of uniformity of composition in the ores is the bane of the furnace-man's life and nowhere does he lead a more strenuous existence than in the Birmingham district. We will take a certain month when the make of iron was 5,719 tons, 77 per cent. being foundry grades. The number of charges was 2,503 during the month, a daily average of 80.7. The furnace was using 80 per cent. of hard ore and 20 per cent. of soft ore in the ore burden. During the 31 days the amount of ore in tons per ton of iron varied from 2.62 to 2.19, or 363 lbs. This was during the entire month. From one day to the next there were differences of 600 lbs. of ore per ton of iron.

In other words, if the furnace could have been charged every day with ore carrying 45.6 per cent. of iron, as was the case on one day, the yield of iron during the month could have been 6,620 tons instead of 5,717, a difference of 901 tons in favor of the better ore. The daily production of iron could have been 213 tons instead of 184 tons.

Furthermore. Not only is the daily yield of the furnace seriously hampered by such irregularities in the ore, the percentage of foundry iron is lessened and the consumption of coke is increased.

A certain coke furnace in the State made once 6,696 tons of foundry iron on a burden composed entirely of brown ore. The composition of the total burden was:

	Per cent.
Brown ore	58.3
Limestone	16.1
Coke	25.6
	100.0

The consumption of materials per ton of iron was:

	Tons of 2,240 lbs.
Ore	2.01
Stone	0.55
Coke	0.87
	3.43

All of the iron made was of foundry grades and the consumption of coke, per ton of iron, was 1,948 lbs. The coke contained 15.7 per cent. of ash and the limestone 2.0 per cent. of silica. The furnace was banked for three days, so that the daily out-put of iron was 239 tons, all foundry iron as already remarked.

This is certainly good practice. The materials were of uniform but not of the highest quality, especially the coke, but the furnace was well handled and a pound of iron was made with 0.87 lb. of coke.

CHAPTER VIII.

CHARCOAL FURNACES.

CONDITION, CAPACITY AND PRODUCTION.

Table No. XXV gives the condition, weekly capacity and production of charcoal furnaces in Alabama since 1882 and Table No. XXVI, gives the furnace burdens, in good practice, over a period of four months. This latter table was prepared several years ago and appeared in the second edition of this work. During the intervening period there have not been any substantial changes in the industry, although the introduction of the dome-kilns for making charcoal has resulted in economies of production. Unless there should be an unexpected demand for charcoal iron it is not likely that the production will exceed 25,000 to 30,000 tons a year for some time to come. The industry has shown remarkable fluctuations. The maximum production of charcoal iron was in 1889 when it reached 98,595 tons. Since that time the output has varied a good deal, reaching its lowest point in 1897 with 14,813 tons. It revived shortly afterwards and rose to 73,000 tons in 1903, but fell to 25,830 tons in 1906.

On the first of January, 1907, there were 5 charcoal furnaces in the State, of which 1 was in blast and 4 were out of blast. On the first of July, 1907, there were 3 in blast and 2 out of blast. During the first half of 1907 the production was 15,737 tons. In 1906 with a total production of charcoal iron in the United States of 433,007 tons Alabama's proportion was 5.0 per cent. In 1903 when the total production was 504,757 tons Alabama's proportion was 14.5 per cent.

TABLE XXV.—*Condition, Weekly Capacity, and Production of Charcoal Iron Furnaces in Alabama,* 1882-1906. *Tons of 2,240 Pounds.*

Year.	Total.	In.	Weekly capacity, tons.	Out.	Weekly capacity, tons.	Production: tons.	
Jan. 1st, 1882	11	10	1,355	1	50	Entire year	49,590
July 1st	11	10	1,475	1	50		
Jan. 1st, 1883	13	8	1,370	5	470	1st half	27,669
July 1st	12	10	2,185	2	170	2nd half	23,575
Jan. 1st, 1884	11	6	1,287	5	707	1st half	25,155
July 1st	11	6	1,236	5	693	2nd half	27,931
Jan. 1st, 1885	10	6	1,075	4	472	1st half	27.954
July 1st	11	7	1,590	4	497	2nd half	41,118
Jan. 1st, 1886	11	7	1,810	4	660	1st half	33,745
July 1st	11	7	1,880	4	680	2nd half	39,579
Jan. 1st, 1887	10	7	1,835	3	560	1st half	42,949
July 1st	10	9	2,345	1	50	2nd half	42,084
Jan. 1st, 1888	10	9	2,145	1	250	1st half	39,105
July 1st	10	10	2,395	---	------	2nd half	44,949
Jan. 1st, 1889	10	9	2,095	1	300	1st half	44,145
July 1st	10	9	1,632	1	210	2nd half	54,465
Jan. 1st, 1890	14	8	1,997	6	1,403	1st half	38,472
July 1st	14	9	1,888	5	1,319	2nd half	60,071
Jan. 1st, 1891	14	8	1,906	6	1,735	1st half	33,286
July 1st	14	6	1,540	6	1,693	2nd half	44,700
Jan. 1st, 1892	14	9	2,357	5	1,681	1st half	45,773
July 1st	14	5	1,285	9	1,890	2nd half	33,683
Jan. 1st, 1893	14	5	1,387	9	1,818	1st half	44,501
July 1st	13	6	1,921	7	1,380	2nd half	22,662
Jan. 1st, 1894	13	1	193	12	2,855	1st half	19,554
July 1st	13	3	906	10	2,310	2nd half	16,524
Jan. 1st, 1895	13	3	644	10	2,525	1st half	2,760
July 1st	13	2	149	11	2,775	2nd half	16,056
Jan. 1st, 1896	12	2	698	10	2,152	1st half	16,199
July 1st	10	3	843	7	1,660	2nd half	13,588

TABLE XXV.—*Continued.*

Condition, Weekly Capacity and Production of Charcoal Iron Furnaces in Alabama. 1882-1906. Tons of 2,240 Pounds.

Year.	Total.	In.	Weekly capacity, tons.	Out.	Weekly capacity, tons.	Production: tons.	
Jan. 1st, 1897	10	1	267	9	2,145	1st half	6,763
July 1st	10	1	280	9	2,145	2nd half	8,150
Jan. 1st, 1898	10	1	492	9	1,980	1st half	18,239
July 1st	10	2	733	8	1,750	2nd half	18,495
Jan. 1st, 1899	7	2	587	5	1,130	1st half	14,604
July 1st	6	3	942	3	745	2nd half	27,065
Jan. 1st, 1900	6	4	1,342	2	350	1st half	30,030
July 1st	6	5	1,428	1	150	2nd half	27,602
Jan. 1st, 1901	6	3	1,014	3	658	1st half	25,008
July 1st	6	4	1,325	2	333	2nd half	28,002
Jan. 1st, 1902	5	2	625	3	793	1st half	23,347
July 1st	5	3	1,199	2	450	2nd half	37,187
Jan. 1st, 1903	7	6	1,833	1	100	1st half	36,599
July 1st	7	6	1,736	1	100	2nd half	36,508
Jan. 1st, 1904	7	4	1,152	3	550	1st half	19,834
July 1st	7	2	681	5	960	2nd half	10,658
Jan. 1st, 1905	6	1	242	5	1,210	1st half	13,702
July 1st	6	1	582	4	885	2nd half	11,846
Jan. 1st, 1906	6	1	270	5	1,310	1st half	10,650
July 1st	5	2	------	3	------	2nd half	15,180
Jan. 1st, 1907	6	1	------	5	------	1st half	15,737
July 1st	5	3	------	2	------	2nd half	19,404
*Jan. 1st, 1908	5	2	------	3	------	1st half	9,337
July 1st	5	1	------	4	------	2nd half	14,478
Jan. 1st, 1909	5	2	------	3	------	1st half	15,996
July 1st	5	2	------	3	------	2nd half	17,645
Jan. 1st, 1910	5	2	------	3	------	1st half	15,339
July 1st	5	1	------	4	------	2nd half	20,365

*The figures in this table from Jan. 1, 1908 to July 1, 1910, inclusive, have been furnished in personal letter by Mr. James M. Swank.—E. A. S.

CHARCOAL FURNACE PRACTICE.

TABLE XXVI.—*Charcoal Furnace Practice, All Brown Ore. Tons of 2,240 Pounds.*

Year.	Per ct. of Total Burden. Ore.	L. Stone.	Coke.	Iron Made: Tons	Per Ct. of Grades 1 to 5.	Consumption tons per ton of iron Bushels for coal Ore	L. Stone	Coal
1893..	58.2	9.8	32.0	1712	78.0	1.84	0.31	100.8
1894..	60.0	10.6	29.4	1753	90.4	1.95	0.34	97.2
1895..	59.6	10.9	29.5	1789	97.7	2.03	0.37	101.8
1896..	58.3	9.6	32.1	1893	88.9	1.80	0.30	100.7

Table XXVI represents 7,147 tons of pig iron. One bushel of charcoal =2,748 cubic inches. Weight per bushed=22.4 lbs. 100 bushels=2,240 lbs.

Table XXVI shows that charcoal furnaces use from 1.80 to 2.03 tons of brown ore, from 0.30 to 0.37 ton of limestone and from 97.2 to 101.8 bushels of charcoal per ton of iron made. In some cases the consumption of charcoal does not exceed 90 bushels and iron has been made with 83 bushels of charcoal per ton of iron. The general practice, however, brings the consumption of charcoal up to about 100 bushels.

The quality of the ore is markedly better than is used by the coke furnaces, ranging from 49.2 to 55.5 per cent. of metallic iron. In this respect what is accomplished by the charcoal iron makers could also be accomplished by the coke iron makers. If the former can and do get brown ore that carries from 49 to 55 per cent. of iron there is no reason why the latter may not secure it. If there were a persistent refusal on the part of the coke iron men to accept brown ore of less than 50 per cent. of iron it would be supplied. The matter is entirely in their own hands. If they wish for better ore and continue to demand it they will secure it. This applies alike to furnaces which are securing their brown ore from outside operators and to companies which mine their own ore. If they do not get better ore it is because they do not insist upon having it. As has been already observed, the best brown ore is seldom to be secured simply by washing the ma-

terial in an ordinary log-washer. There are four distinct processes which should be applied to brown ore as it is ordinarily met with, washing in a log-washer, crushing, jigging and calcining. In this way it is possible to secure the best results and in no other way. There is no economy in pursuing the methods which have heretofore been in use for they have shown an utter inability to supply ore of uniform quality, to say nothing of the best quality.

Grading of Pig Iron.

W. H. BRANNON.

In the grading of pig iron there are today recognized 12 grades viz: No. 2 Silvery, No. 1 Silvery, No. 2 Soft, No. 1 Soft, No. 1 Foundry, No. 2 Foundry, No. 3 Foundry, No. 4 Foundry, Basic, Gray Forge, Mottled and White.

No. 2 Silvery contains from 5 to 5.50 per cent. of silicon, has very little or no granulation, is almost smooth and has a galvanized appearance. No 1 Silvery has some granulation, a smooth face and contains from 4.50 to 5.00 per cent. of silicon. Both these irons are weak in fracture and show a fine, silvery lustre on a fresh face, and are flaky. They should exhibit no dark spots. The crystallization is obscure. The difference between them, on the yard, is mainly one of granulation. They are the hottest irons and contain more silicon and less combined carbon than any of the other grades. The carbon is almost entirely in the shape of graphite, but the large excess of silicon prevents this ingredient from making the iron dark.

No. 2 Soft contains 2.75 to 3.25 per cent. of silicon and No. 1 Soft from 3.00 to 3.50 per cent. They are both of a light color, smooth face and weak fracture. A distinct granulation begins to be apparent in No. 2 Soft, which is more pronounced in No. 1 Soft, but in neither of these grades is the granulation so marked as in the foundry irons. The soft irons are darker in color than the silvery irons, but lighter in color than the foundry irons; the granulation is not so jagged as in the foundry irons. In particular they do not show a silvery appearance and are not flaky. The increasing ratio of graphitic

to combined carbon begins to manifest itself in the soft irons by a darkening of the color, as compared with the silvery irons.

No. 1 Foundry contains from 2.25 to 2.75 per cent. of silicon, has a very open and regular granulation extending throughout the entire face, and a dark gray color. The crystalization is well marked and the face is rough to the feel. The difference between this and No. 2 Foundry, which contains from 2.00 to 2.50 per cent. of silicon, is the same in kind as exists between the two silvery and the two soft irons and is chiefly one of granulation. In No. 2 Foundry the grain is not so open as in No. 1, nor is the crystallization so coarse. The color may be as dark in the one as in the other, but in No. 1 Foundry there is a deep blackish gray color which is absent in No. 2.

No. 3 Foundry contains from 1.75 to 2.00 per cent. of silicon and resembles No. 1 and No. 2 in structure, but the granulation is much less marked. The crystalization is finer than in No. 2 F. and the color, while still dark, is not so pronounced.

No. 4 Foundry, once termed Foundry Forge, shows the dark color of the other foundry irons but the granulation is closer and the crystalization finer. It carries from 1.25 to 1.75 per cent. of silicon.

Taken together, the foundry irons are distinguished by a dark gray color, open grain and well marked crystalization. These three characteristics are seen to the best advantage in No. 1 Foundry.

Basic iron is iron intended for conversion into steel in the open hearth steel furnace. It should carry not more than 1.00 per cent. of silicon and not more than 0.05 per cent. of sulphur. It is sold on analysis.

Gray Forge is the old No. 2 Mill. It has from 1.25 to 1.50 per cent. of silicon and shows a pebbled granulation in the center, with mottled edges about one-quarter of an inch deep all around. It has a blistered and pitted face and is frequently honey-combed on the fractured end, some of the holes being an eighth of an inch deep.

Mottled iron has from 1.00 to 1.25 per cent. of silicon, shows no granulation but has a pepper-and-salt appearance on a fresh face. It begins to show an increasing amount of combined carbon, about one-half of the total carbon being in this condition.

White iron has from 0.75 to 1.00 per cent. of silicon, shows no granulation, and is sometimes as white as bleached linen. It carries very little graphitic carbon and is generally high in sulphur. It is very hard.

Each of the grades mentioned has its own functions to perform in the manufacture of finished products. Gray Forge, mottled and white are largely taken by the rolling mills, a small amount being used also by the foundries. All of the other grades, with the exception of basic, are strictly foundry irons.

The fracture of pig iron does not figure so prominently in grading now as it did several years ago. The chemical composition, especially the content in silicon and sulphur is of more importance in establishing the grade now than was the case five or six years ago.

At that time southern pig iron was sold almost entirely by fracture whereas now the tendency is towards the purchase on analysis and the extension of this principle of grading would be more satisfactory to all parties concerned. It is merely a question of time when all southern pig iron will be sold almost entirely on analysis, with special reference to the amount of silicon and sulphur present and this change in the trade will be greatly helped by the use of pig-casting machines and the discarding of the present methods of casting in sand.

Mr. Brannon calls attention to the fact that the content of silicon in Alabama irons is in some grades markedly less now than it was a few years ago. These differences may be set forth in a table giving the composition of the various grades, with respect to silicon, now and when the second edition of this book was published in 1898.

TABLE XXVII.—*Showing the Differences in Silicon Content of Pig Irons,* 1898-1907.

SILICON.

	1898.	1907.
No. 2 Silvery	5.00 to 5.50	5.00 to 5.50
No. 1 Silvery	4.50 to 5.00	4.50 to 5.00
No. 2 Soft	3.50 to 4.00	2.75 to 3.25
No. 1 Soft	3.00 to 3.50	3.00 to 3.50
No. 1 Foundry	2.50 to 3.00	2.25 to 2.75
No. 2 Foundry	2.25 to 2.50	2.00 to 2.50
No. 3 Foundry	2.00 to 2.25	1.75 to 2.00
No. 4 Foundry	1.75 to 2.00	1.25 to 1.75
Basic	Not over 1.00	Not over 1.00
Gray Forge	1.50 to 1.75	1.25 to 1.50
Mottled	1.25 to 1.50	1.00 to 1.25
White	1.25 to 1.50	0.75 to 1.00

In the silvery irons, which are the hottest irons, there has been no change, but, beginning with the soft irons, the differences run all the way through, with the exception of basic iron intended for the open-hearth steel furnaces. It would be interesting to know whether this change has been induced by the increasing proportion of hard ore, but the data is not now to hand.

The use of the pig-casting machine has had much to do with the sale of iron on analysis. It does not, of course, alter the grade of the iron, but it does change the grain and physical appearance. In addition to this it enables the furnace-man to dispense with the 28 lbs. of sand which adhered to a ton of iron cast in the old way. The pig iron ton was formerly taken at 2,268 lbs. of which 2,240 lbs. were iron and 28 lbs. were sand. So long as the sand-cast methods was in use (and it is still used) a ton of pig iron contained about 28 lbs. of sand which adhered to the iron in the casting process. While a good portion of this sand falls off as the iron is handled from the furnace to the consumer yet a good deal remained. The modern method of casting in iron moulds gives a much cleaner iron and has largely aided in bringing about a demand for the sale of iron on analysis. The purchaser, no longer able to grade iron so accurately, owing to changes in the grain, etc., came naturally to asking for the analysis. No. 2 F. did not look like the No. 2 F. he had been accustomed to buy, so he began to ask about the silicon content, graphitic and com-

bined carbon, etc., and is now extending his inquiries to include manganese.

In order to have some data on this subject an inquiry was addressed to all of the foundries and machine shops in the State asking if they favored the purchase of pig iron on analysis. Replies have been received from 95 per cent. of them, representing 98 per cent. of the consumption in Alabama. The sentiment is almost unanimously in favor of the purchase of pig iron on analysis and is shared alike by the large and the small consumers. In the face of these replies there can be no question of the strength of the tide that is setting in towards the purchase of iron on chemical analysis. Just what details of composition will be demanded remains to be seen, but silicon and the two carbons seem to be most in favor. The nature of the products will determine the demands for detailed composition. Some foundrymen are beginning to ask about manganese, but the demand for this element is not very pronounced, as yet.

With the extension of the foundry and machine industry in the State and the manufacture of higher grade products the demand for chemical analysis, be it in detail or not, will become more accentuated.

The control of the composition of basic iron for the steel furnaces is, of course, a necessity and receives the greater part of the attention given to the analysis of the different grades of iron. In this iron the silicon is kept, as far as possible, below 1 per cent. and the sulphur below 0.05 per cent. In such iron the phosphorus varies from 0.70 to 0.80 per cent., according to the amount of this element in the stock.

Production of Pig Iron.

Table XXVIII.—*Production of Pig Iron in Alabama, and the United States, 1872 to 1910. Tons of 2.240 pounds.*

Year.	In Alabama.			In United States.	Ala. Per Cent. of Total.
	Charcoal	Coke	Total		
1872	11,171	----------	11,171	2,548,713	0.44
1873	19,895	----------	19,895	2,560,963	0.77
1874	29,342	----------	29,342	2,401,262	1.22
1875	22,418	----------	22,418	2,023,733	1.11
1876	20,818	1,262	22,080	1,868,961	1.18
1877	22,180	14,643	36,823	2,066,594	1.78
1878	21,422	15,615	37,037	2,301,215	1.61
1879	28,563	15,937	44,500	2,741,853	1.62
1880	33,763	35,232	68,995	3,375,912	2.04
1881	49,483	48,107	97,590	4,144,254	2.35
1882	49,590	51,093	100,683	4,623,323	2.18
1883	51,237	102,750	153,987	4,595,510	3.35
1884	53,078	116,264	169,342	4,097,868	4.13
1885	69,261	133,808	203,069	4,044,425	5.02
1886	73,312	180,133	253,445	5,683,329	4.46
1887	85,020	176,374	261,394	6,417,148	4.07
1888	84,041	317,289	401,330	6,489,738	6.18
1889	98,595	608,034	706,629	7,603,642	9.29
1890	98,528	718,383	816,911	9,202,703	8.87
1891	77,985	717,687	795,672	8,279,870	9.61
1892	79,456	835,840	915,296	9,157,000	9.99
1893	67,163	659,725	726,888	7,124,502	10.20
1894	36,078	556,314	592,392	6,657,388	8.89
1895	18,816	835,851	854,667	9,446,308	9.05
1896	29,787	892,383	922,170	8,623,127	10.70
1897	14,913	932,918	947,831	9,652,680	9.82
1898	36,734	996,942	1,033,676	11,773,934	8.78
1899	41,669	1,042,236	1,103,905	13,620,703	8.18
1900	57,632	1,126,705	1,184,337	13,789,242	8.60
1901	53,010	1,172,202	1,225,212	15,878,354	7.71
1902	60,534	1,411,677	1,472,211	17,821,307	8.26
1903	73,107	1,488,291	1,561,408	18,009,252	8.66
1904	30,492	1,423,021	1,453,513	16,497,033	8.81
1905	25,548	1,578,514	1,604,062	22,992,380	6.90
1906	25,830	1,649,018	1,674,848	25,307,101	6.62
1907	35,141	1,651,533	1,686,694	25,781,361	6.54
1908	23,815	1,373,199	1,397,014	15,936,018	8.77
1909	33,641	1,729,976	1,763,617	25,795,471	6.84
1910	35,704	1,903,443	1,939,147	27,303,567	7.12
Total	1,778,772	26,512,419	28,291,191	388,037,743	------

Alabama reached its highest percentage of the entire production of pig iron in 1896, viz: 10.70. It is noteworthy that during the panic of 1907-1908 its percentage increased considerably.

Production of Iron Ore, Coal, Coke and Pig Iron.

Table XXIX.—*Production of Iron Ore, Coal, Coke and Pig Iron in Alabama,* 1870-1910.

Year	Iron Ore, Tons of 2,240 lbs.	Coal, Tons of 2,000 lbs.	Coke, Tons of 2,000 lbs.	Pig Iron—Tons of 2,240 lbs.		
				Coke Iron.	Charcoal Iron.	Total
1870	11,350	11,000	---------	---------	---------	---------
1871	---------	15,000	---------	---------	---------	---------
1872	22,000	16,800	---------	---------	11,171	11,171
1873	39,000	44,800	---------	---------	19,895	19,895
1874	58,000	50,400	---------	---------	29,342	29,342
1875	44,000	67,200	---------	---------	22,418	22,418
1876	44,000	112,000	---------	1,262	20,818	22,080
1877	70,000	196,000	---------	14,643	22,180	36,823
1878	75,000	224,000	---------	15,615	21,422	37,037
1879	90,000	280,000	---------	15,937	28,563	44,500
1880	171,139	323,972	60,781	35,232	33,763	68,995
1881	222,000	420,000	109,033	48,107	49,483	97,590
1882	250,000	896,000	152,940	51,093	49,590	100,683
1883	385,000	1,568,000	217,531	102,750	51,237	153,987
1884	420,000	2,240,000	244,009	116,264	53,078	169,342
1885	505,000	2,492,000	301,180	133,808	69,261	203,069
1886	650,000	1,800,000	375,054	180,133	73,312	253,445
1887	675,000	1,950,000	325,020	176,374	85,020	261,394
1888	1,000,000	2,900,000	508,511	317,289	84,041	401,330
1889	1,570,000	3,572,983	1,030,510	608,034	98,595	706,629
1890	1,897,815	4,090,409	1,072,942	718,383	98,528	816,911
1891	1,986,830	4,759,781	1,282,496	717,687	77,985	795,672
1892	2,312,071	5,529,312	1,501,571	835,840	79,456	915,296
1893	1,742,410	5,136,935	1,168,085	659,725	67,163	726,888
1894	1,493,086	4,397,178	923,917	556,314	36,078	592,392
1895	2,199,390	5,693,775	1,444,339	835,851	18,816	854,667
1896	2,041,793	5,748,697	1,689,703	892,383	29,787	922,170
1897	2,050,014	5,893,770	1,395,252	932,918	14,913	947,831
1898	2,401,748	6,535,283	1,663,020	996,942	36,734	1,033,676
1899	2,662,943	7,593,416	1,787,809	1,042,236	41,669	1,083,905
1900	2,759,247	8,394,275	2,110,837	1,126,705	57,632	1,184,337
1901	2,801,732	9,099,052	2,148,911	1,172,202	53,010	1,225,212
1902	3,574,474	10,354,570	2,552,246	1,411,677	60,534	1,472,211
1903	3,684,960	11,654,324	2,693,497	1,488,291	73,107	1,561,398
1904	3,699,881	11,262,046	2,340,219	1,423,021	30,492	1,453,513
1905	3,782,831	11,866,069	2,576,986	1,578,514	25,548	1,604,062
1906	3,995,098	13,107,963	3,034,501	1,649,018	25,830	1,674,848
1907	4,039,453	14,250,454	3,021,794	1,651,553	35,141	1,686,694
1908	3,734,438	11,604,593	2,362,666	1,373,199	23,815	1,397,014
1909	4,321,252	13,703,450	3,085,824	1,729,976	33,641	1,763,617
1910	4,801,275	16,111,462	3,249,027	1,903,443	35,704	1,939,147
Total	68,283,507	205,976,969	45,527,850	26,512,419	1,778,772	28,291,191

CHAPTER IX.

LIST OF COKE FURNACES.

ALABAMA CONSOLIDATED COAL AND IRON COMPANY.

General Offices: First National Bank Building, Birmingham, Alabama.

Officers at New York: Jos. H. Hoadley, President, No. 165 Broadway; Wm. R. Sheldon, Treasurer, No. 165 Broadway.

Officers at Birmingham: H. S. Matthews, Vice-President and General Manager; J. W. Porter, General Sales Agent; A. G. and E. D. Smith, Southern Counsel.

Furnaces.

At Ironaton, Talladega County, two (2) stacks. No. 1, 70x17 1-6, built to use charcoal in 1884 and blown in on that fuel April 16th, 1885; changed to coke in 1895, rebuilt in 1896-7; four (4) Whitwell-Cowper stoves. No. 2, 76x16, built in 1889-90 to use charcoal and blown in on that fuel in 1891, changed to coke in 1900; rebuilt in 1902; four (4) Whitwell-Cowper stoves.

Fuel: Alabama coke.
Ore: Local brown hematite.
Product: Foundry pig iron.
Total Annual Capacity: 130,000 tons.
Brand: "Clifton."

At Gadsden, Etowah County two (2) stacks. No. 1, 78x18, built in 1905-7; four (4) 20x85 stoves. No. 2, 86x19, built in 1902-3 and blown in August 22nd, 1903; four (4) 85x20 Whitwell stoves.

Fuel: Coke.
Ores: Red and brown hematite.
Product: Foundry pig iron.

Total Annual Capacity: 150,000 tons.
Brand: "Etowah."

Iron Ore Lands, Coal Lands, Coke Ovens, Etc.

The Company has acquired the Gate City property, near Birmingham, comprising about 1,800 acres of land. This property contains large deposits of red fossiliferous iron ore as well as deposits of limestone, dolomite, building stone, sand, etc.

It has also acquired the Standard Coal Company's property, in Tuscaloosa County, Alabama, which contains 32.211 acres of coal and timber land. It is estimated that from 18,000 to 24,000 acres contain workable seams of coal. About 14,000 acres are covered with yellow pine timber. There are now 600 completed coke ovens on the property.

The Company acquired with the Clifton Furnaces about 2,500 acres of mineral lands and 33,292 acres of other lands, of which from 10,000 to 12,000 acres are well timbered. With the Gadsden-Alabama furnace it acquired about 730 acres of ore and other lands.

In addition to the above the Company has acquired about 1,207 acres of land near Gadsden, Alabama, containing deposits of red iron ore. It has also acquired a large acreage of brown iron-ore property available for its furnaces at Ironaton and Gadsden.

At Hematite, Georgia, it has acquired 1,700 acres of brown iron-ore lands. These mines are equipped with ore washers.

The Company has also purchased tracts of coal lands at Brookwood, Alabama and in the vicinity of Birmingham.

It owns valuable red iron-ore properties near Attalla and Gadsden, the latter property being within one mile of the Gadsden-Alabama Furnaces and the former property within five miles. On both of these properties there are developed mines with a capacity at present of from 400 to 600 tons of iron ore per day.

In 1901 the Company acquired the property of the Jefferson Coal & Railway Company, at Lewisburg, near Birmingham, comprising over 3,000 acres, all underlaid with coal. On this property there are two coal openings and 350 coke ovens. Steam and domestic coals are mined and furnace and foundry cokes are made.

THE ANNISTON IRON CORPORATION,

Anniston, Calhoun County, Alabama.

Officers: H. E. McWane, President, Lynchburg, Va.; Ernest Williams, Vice-President, Lynchburg, Va.; L. H. McWane, Treasurer, Lynchburg, Va.; S. G. Harris, Secretary, Lynchburg, Va.; M. H. Maury, General Manager, Anniston, Ala.

Hickman, Williams & Co., selling agents.

Two stacks at Anniston, Ala., "A" and "B"; "A" 19x75, "B" 17x75. Each stack has four stoves. Furnace "A" built in 1888-89, blown in October, 1889; rebuilt in 1901-02. Furnace "B" built in 1887-89, blown in June, 1892; rebuilt in 1896 and 1903.

Fuel: Alabama coke.

Ores: Local brown.

Product: Foundry and forge pig iron.

Capacity: Total annual capacity, 120,000 tons.

Brand: "Woodstock."

Furnace "B" has no lining and is not in shape to operate at this time.

Connected with the furnaces are 376 coke ovens.

CENTRAL IRON & COAL COMPANY.

Officers: President, Waddill Catchings, No. 90 West St., New York, N. Y.; Vice-President, J. W. Shook, Tuscaloosa, Ala.; V. P. and Treas, de Courcey Cleveland, No. 90 West St., New York, N. Y.; Secretary and assistant Treasurer, W. H. Feltt, No. 90 West St., New York, N. Y.

Furnace: At Holt, near Tuscaloosa, Tuscaloosa county, Alabama. One stack 85x19, built in 1901-3, and first blown in August 4, 1903; four (4) Foote stoves, each 19x85 feet.

Fuel: Coke.

Ores: Local red and brown, and nodules (manufactured from pyrite cinders).

Product: Foundry pig iron.

Annual Capacity: 72,000 tons.

Brand: "Tuscaloosa."

Connected with the furnace are 164 bee-hive, and 40 by-product ovens.

Description of Coal, Ore and Limestone Properties in Alabama.

Coal mines and washers at Kellerman, Tuscaloosa County, Alabama.

Limestone quarry at Vance, Tuscaloosa County, Alabama.

Brown ore mines at Giles and Friedman (near Woodstock) Tuscaloosa County, Alabama.

Red ore mines at Valley View, Jefferson County, Alabama.

Furnace entirely rebuilt in 1912.

THE CENTRAL FOUNDRY COMPANY.

Officers: President, Waddill Catchings; Vice Pres. and Treasurer, de Courcey Cleveland; Secretary, Charles E. Marlor; Asst. Secretary, Robert R. Rust; Asst. Treasurer, W. H. Feltt.

Principal Office: No. 90 West St., New York, N. Y.

Principal Foundry: At Holt, near Tuscaloosa, Tuscaloosa County, Ala.

This foundry has a capacity of 450 tons of finished castings per day and is fully equipped with molding machines, mold and equipment conveyors and sand conveyor; built in 1912. Plant is designed to use hot metal from the furnace of the Central Iron & Coal Company.

The Central Foundry Company has other plants at Anniston, Ala., Bessemer, Ala., Vincennes, Ind., Baltimore, Md., Newark, N. J., and Medina, N. Y.

The Company manufactures universal pipe and fittings, soal pipe and fittings, F. & W. fittings, and miscellaneous castings.

The Central Foundry Company owns the entire capital stock of the Central Iron and Coal Company.

JENIFER FURNACE COMPANY.

Jenifer, Talladega County, Alabama.

Officers: J. W. McQueen, Receiver, Woodward Bldg., Birmingham, Ala.

Furnace: At Jenifer, Talladega County, Alabama. One stack 75x15, built in 1901 and first put in operation September

26th, 1901; one improved Whitwell and two Hugh Kennedy stoves.

Fuel: Alabama coke.

Ores: Local brown hematite from the company's mines.

Product: Foundry and grey forge pig iron.

Annual Capacity: 50,000 tons.

Brand: "Jenifer."

The Company owns 100 coke ovens at the Weller mines, south of Bessemer, on the Birmingham Mineral railroad. It also owns 11,000 acres of land, railroad from the furnace to its brown ore mines, near Jenifer, two ore washers, steam shovel, dinkey locomotives, cars, etc.

LOOKOUT MOUNTAIN IRON COMPANY.

This Company was organized in April, 1902, with a capital stock of $1,000,000, to acquire and hold some 15,000 acres of coal and iron ore lands in DeKalb County, Alabama and Dade County, Georgia. The officers were J. G. Battelle, President, Columbus, Ohio; Geo. B. McCormack and Erskine Ramsay, Vice-Presidents, Birmingham, Ala.; James Bowron, Chairman, Birmingham, Alabama; J. F. Stiens, Secretary and Treasurer, Battelle, Alabama; C. E. Bowron, Superintendent, Battelle, Alabama; John Dowling, Furnace Superintendent, Battelle, Alabama.

The property was sold in 1905 and is at present owned by W. S. Rowe, Trustee, care First National Bank, Cincinnati, Ohio.

At Battelle, DeKalb County, Alabama. One stack, 85x19½, built in 1903-4 and put in blast July 1904, four 4-pass Whitwell stoves, each 20x80 feet.

Fuel: Coke made in ovens owned by the Company.

Ore: Red hematite obtained from the Company's mines. which are located about one-half mile from the furnace.

Product: Foundry pig iron.

Annual Capacity: 100,000 tons.

Brand: "Battelle."

Connected with the furnace are 150 coke ovens with an annual capacity of 75,000 net tons.

Plant now idle.

NORTHERN ALABAMA COAL, IRON AND RAILWAY COMPANY.

Talladega, Talladega County, Ala.

Officers: Sidney H. March, President, No. 25 Broad St., New York, N. Y.; Y. VandenBerg, Vice-President, No. 25 Broad St., New York, N. Y.; Oscar Freund, Treasurer, No. 25 Broad St., New York, N. Y.

Rogers, Brown & Co., Selling Agents, New York, N. Y.

Furnace: At Talladega County, Alabama. One stack, 72x18, built in 1889 and blown in October 5th, 1889; remodeled in 1900-01; three Whitwell stoves, each 62x26.

Fuel: Alabama coke.

Ores: Local brown and red hematite.

Product: Foundry and forge pig iron.

Annual Capacity: 40,000 tons.

Connected with the furnace are 182 coke ovens.

REPUBLIC IRON & STEEL COMPANY (SOUTHERN DISTRICT.)

Officers: John A. Topping, Chairman, No. 17 Battery Place, Whitehall Building, New York City. Thomas J. Bray, President, Republic Building, Youngstown, Ohio; Harry L. Rownd, Vice-President and Treasurer, Republic Building, Youngstown, Ohio; Richard Jones, Jr., Secretary and General Attorney, Republic Building, Youngstown, Ohio.

Charles T. Fairbairn, Manager, Southern District, Birmingham, Alabama.

The general offices of the Company are in the Republic Building, Youngstown, Ohio.

Pioneer Furnaces, Thomas, Jefferson County, Alabama. Two stacks, each 90x18, one stack, 85x20. No. 1 built in 1886-88; blown in May 15, 1888; rebuilt and remodelled in 1903. No. 2 built in 1889-90 and blown in February 22, 1890; rebuilt and remodelled in 1903. No. 3 built in 1901-02 and blown in June 13, 1902; remodelled in 1908. Twelve Massick & Crooke stoves.

Fuel: Alabama coke from the Company's ovens.

Ores: Red and brown hematite from the Company's mines.

Product: Foundry and mill pig iron.

Total Annual Capacity: 300,000 tons.

Brand: "Pioneer."

(Plate XIV shows the dolomite quarry in close proximity to the furnaces.)

SHEFFIELD COAL AND IRON COMPANY.

Sheffield, Colbert County, Alabama.

Officers: E. C. Rust, President, Birmingham, Alabama; James Gayley, Vice-President, No. 71 Broadway, New York; J. R. Floyd, Jr., Treasurer, No. 71 Broadway, New York; W. L. Reed, Secretary, No. 71 Broadway, New York; W. M. Jones, Assistant Secretary and Assistant Treasurer, No. 71 Broadway, New York.

Fuel: Stonega coke from Virginia.

Rogers, Brown & Co., Selling Agents, New York.

At Sheffield: Three stacks, each 75x18, built in 1887-8 No. 1 blown in September, 1888. No. 2 in October, 1889, and No. 3 in April, 1896.

No. 1, rebuilt in 1900 and Nos. 2 and 3 remodeled in 1897. All remodeled and reconstructed in 1903. Twelve Whitwell Cowper stoves.

Fuel: Stonega coke from Virginia.

Ores: Alabama and Tennessee brown hematite from the Company's mines.

Product: Foundry pig iron.

Total Annual Capacity: 210,000 tons.

Brand: "Sheffield."

SLOSS-SHEFFIELD STEEL AND IRON COMPANY.

General Offices: Woodward Building, Birmingham, Alabama,

Principal Office: Jersey City, New Jersey.

Officers at Birmingham: J. C. Maben, President; J. W. McQueen, Vice President and General Sales Agent: E. L. Morris, Secretary and Treasurer; E. J. Thomas, Jr., Auditor; W. B. Dowell, Purchasing Agent.

Sales Agents and Offices: J. W. McQueen, Gen. Sales Agent, Birmingham, Ala.; Hugh W. Adams, 15 Beekman St., New York, N. Y.; William J. Breen, 84 State St.; Boston, Mass.: J. K. Dimmick & Co., Land Title Bldg., Philadelphia, Pa.; Domhoff, Joyce & Co., Cincinnati, O.; David Evans, 804

The Rookery, Chicago, Ill.; J. G. Armistead, Richmond, Va.; J. B. Fisher, 1113 Central National Bank Bldg., St. Louis, Mo.; Zimmerman, Wells, Brown Co., Portland, Ore.; Hardy Greenwood, 406 Scollard Bldg., Dallas, Tex.; Edwin Haas, Atlanta, Ga.; H. S. DeNeefe, 320 Temple Court, Chattanooga, Tenn.; William Jacks & Co., 41 St. Vincent Place, Glasgow, Scotland.

Kinds of Pig Iron Made: Foundry and mill.

Brands for Pig Iron: "Sheffield," "Lady Ensley," "Florence," "Sloss."

Capital Stock: $20,000,000.00 of which $10,000,000.00 is 7% non-cumulative preferred and $10,000,000.00 is common; $6,700,000.00 of preferred and $10,000,000.00 common stock have been issued for the present requirements of the Company and the balance will be reserved for future use. The bonded indebtedness attached as a lien only on the property of the Sloss Iron and Steel Company, consists of $2,000,000.00 of 6% and $2,000,000.00 of 4½% bonds.

Registrar: Lawyers Title Insurance & Trust Co., 160 Broadway, New York, N. Y.

Transfer Agents: Central Trust Company, 54 Wall Street, New York, N. Y.

The Sloss-Sheffield Steel and Iron Company operates or controls the following works:

Hattie Ensley Furnace, Sheffield, Colbert County, Alabama. One stack 75x17 built in 1887, and first put in blast December 31st, 1887. Remodeled in 1900; rebuilt in 1903, and still in blast. Five stoves.

Fuel: Coke.

Ore: Local brown hematite.

Product: Foundry pig iron.

Annual Capacity: 70,000 tons.

Brand: "Sheffield."

Lady Ensley Furnace, Sheffield, Colbert County, Alabama. One stack 75x17, built in 1887-9 and first blown in April 25th, 1889. Remodeled in 1900-1 and 1906. Five stoves.

Fuel: Coke.

Ore: Local brown hematite.

Product: Foundry and mill pig iron.
Annual Capacity: 70,000 tons.
Brand: "Lady Ensley."

Philadelphia Furnace, Florence, Lauderdale County, Alabama. One stack 75x17, commenced by the W. B. Wood Furnace Company in 1887 and completed by the Florence Cotton & Iron Co., in 1890-1. Remodeled in 1900 and rebuilt in 1903 and 1906-7. Blown in August 9th, 1907. Five stoves, each 70x20.
Fuel: Coke.
Ore: Brown hematite from the Company's mine at Russellville, Franklin County, Alabama.
Product: Foundry pig iron.
Annual Capacity: 70,000 tons.
Brand: "Florence."

Sloss Furnaces, Birmingham, Jefferson County, Alabama. Four stacks, No. 1, 82½x18, built in 1881-2; put in blast April 12th, 1882 and rebuilt in 1895, 1901, and 1905. No. 2 73x18 built in 1882 and rebuilt in 1902 and 1906. No. 3 73x17 built in 1887-8; blown in October 1888 and rebuilt in 1901. No. 4 73x17, built in 1887-9; blown in February 1889, and rebuilt in 1901. Five Whitwell, eight Gordon-Whitwell-Cowper and three two-pass 18x70 and three new four-pass stoves.
Fuel: Coke.
Ores: Red fossiliferous, hard and soft, and brown hematite; ores and coal mined on the Company's property within ten to fifteen miles of the furnaces.
Total Annual Capacity, of seven furnaces, 435,000 gross tons.

By the purchase of the four blast furnaces of the Sloss Iron and Steel Company, the Sloss-Sheffield Steel and Iron Company acquired 951 coke ovens, 30,000 acres iron ore lands, 31, 000 acres of coal lands and extensive limestone quarries, 573 coke ovens have since been added.

In addition to the above this Company has purchased 25,000 acres of coal lands south of Jasper, Alabama, on which property two mines are being operated with a production of 500.-000 tons of coal annually, and it acquired through the purchase of the Lady Ensley properties 12,000 of developed coal lands on the Frisco Railroad with 200 coke ovens, coal washer,

etc. (these mines have a capacity of 1,000 tons daily) and 20,000 acres of brown ore lands in Franklin and Colbert Counties, Alabama, which have been fully developed to a capacity of 1,200 tons a day, with five double log washers, twelve steam shovels, and twenty-three dinkey locomotives.

The Sloss-Sheffield Steel and Iron Company is now mining 7,000 tons of coal per day. It has also a capacity of 475,000 net tons of coke and 800,000 gross tons of iron ore per year.

SOUTHERN STEEL COMPANY; OR, SOUTHERN IRON AND STEEL COMPANY.

Note: The Southern Steel Company went into the hands of receivers in November, 1907. In February 1909, its properties were taken over by the Southern Iron and Steel Company, organized in May, 1908. On August 1, 1912 the latter Company passed under the management of James Bowron, Sole Trustee, with the following Staff: H. S. Smith, General Sales Agent; A. R. Forsythe, Treasurer; C. A. Moffett, Manager of Steel Works; B. F. Tyler, General Purchasing Agent; J. E. Strong, General Superintendent of Mines; H. H. Knight, Traffic Manager; C. C. Brown, Assistant General Sales Agent; T. M. Nesbitt, Auditor.

General Offices: Brown-Marx Building, Birmingham, Ala.

Capital Stock: Preferred, $7,000,000.00 authorized; $1,100,000.00 in Treasury. Common, $10,000,000.00 authorized; $100,000.00 in Treasury.

Furnace Plants.

At Chattanooga, Tenn., modern furnace, 75x16, four blowing engines, four stoves. Furnace equipped with modern Brown skip hoist. Coke supply to be drawn from Dunlap, red ore from Ringgold, Estelle and Rising Fawn, and brown ore from Bartow, Ga.

Capacity: 7,000 tons monthly, or 84,000 tons per annum.

At Trussville, Ala., blast furnace 17.9x80, equipped with Brown skip hoist, five stoves, four blowing engines. Furnace recently blown out and not now in operation. Coal washer and 300 bee-hive coke ovens, monthly capacity of 10,000 tons;

212 workmen's houses are attached to this plant. Furnace runs on coke from Company ovens, red ore from Crudup and brown ore from Bartow and Oremont, Ga.

Capacity: 6,000 tons monthly, or 72,000 tons per annum.

This stack was built in 1887-89, blown in April 1899; rebuilt in 1901 and 1903.

Brand: "Trussville."

At Alabama City, (near Gadsden), Etowah County, Alabama, blast furnace, 90x20; equipped with McKee skip hoist. four stoves, four blowing engines. Also electric power station, four generators producing power for the blast furnace and blowing mill and pumping station, adjoining.

Capacity: 8,000 tons monthly, 96,000 tons per annum.

Total annual pig iron capacity of Alabama Plants, 168,000 tons. (Plate XXII.)

TENNESSEE, COAL, IRON AND RAILROAD COMPANY.

Note: A controlling interest in the Tennessee Coal, Iron & Railroad Company was acquired by the United States Steel Corporation in November, 1907.

General Offices: Brown-Marx Building, Birmingham, Alabama.

Officers at New York: Thomas Murray, Assistant Secretary, 71 Broadway, N. Y.

Officers at Birmingham: George G. Crawford, President; Frank H. Crockard, Vice President; L. T. Beecher, Secretary and Treasurer; W. A. Major, Purchasing Agent; F. A. Burr, General Manager of Sales.

Sales Offices: Birmingham, Ala., Brown-Marx Building; Boston, Mass., Telephone Building; Buffalo, N. Y., Ellicott Square Building; Chicago, Ill., Commercial Nat'l. Bank Building; Cincinnati, Ohio, Union Trust Building; Cleveland, Ohio. Rockefeller Building; Denver, Colorado, Equitable Building; Detroit Michigan., Union Trust Building; New York City, N. Y., 30 Church Street; New Orleans, La., Mai-

son Blanche; Philadelphia, Pa., Pennsylvania Building; Pittsburg, Pa., Carnegie Building; Portland, Oregon, Ainsworth Building; San Francisco, Calif., Crocker Building; St. Louis, Mo., Third National Bank Building; St. Paul, Minn., Pioneer Press Building.

Kinds of Pig Iron Made: Foundry, forge, mill, and basic.

Brands: "Ensley Basic Open Hearth," for billets, etc.; for *Steel rails*: "Tennessee Open Hearth."

For Pig Iron: "Ensley," "Bessemer," "De Bardeleben," "Oxmoor," "Eureka," "Alice," and "South Pittsburg."

For Coal: "Pratt," "Blocton," "Cahaba," "Blue Creek," "Henry Ellen," and "Whitwell."

For Coke: The blast furnaces of the Tennessee Company derive their entire supply of coke from the by-product ovens, one plant of which, of the Koppers type (280 ovens), is located at Corey, while the second, of the Semet-Solvay type (240 ovens), is located immediately in the rear of the Ensley blast furnaces, the coke being transported on special equipment directly from the ovens to the blast furnace stock house. These plants and the blast furnaces at Ensley are illustrated in Plates XVII, XVIII and XX. A.

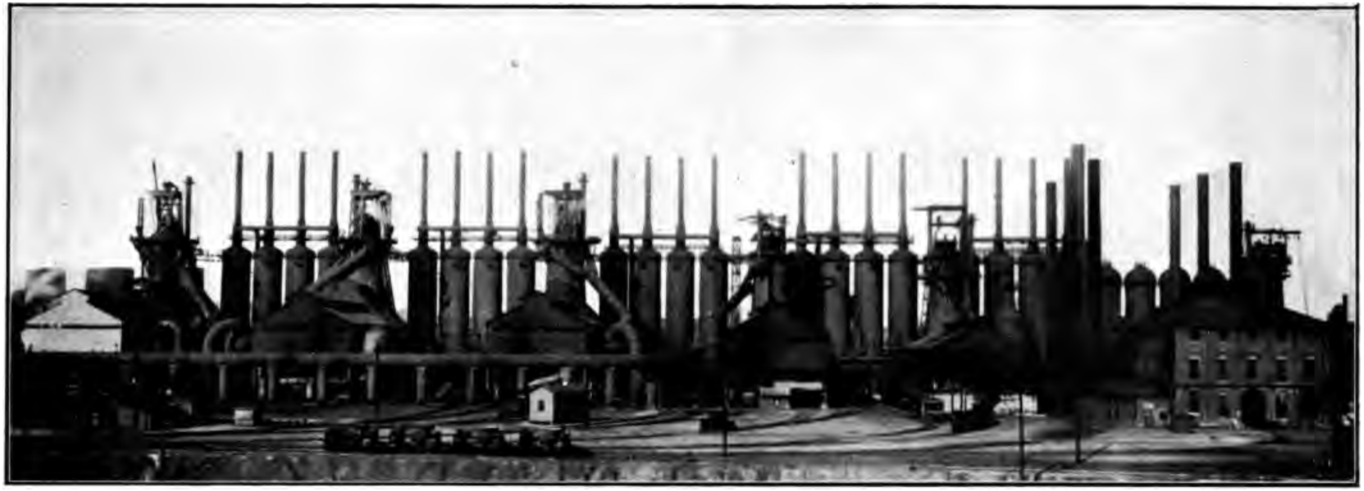
The plant of the Tennessee Coal, Iron and Railroad Company, commonly known as the By-Product Coke Plant, is situated in the immediate vicinity westward of Corey and along the Ensley Southern and Birmingham Southern tracks. The ground covered by the present plant is about 40 acres without considering the various railroad approaches from the several track systems.

The plant consists of 280 regenerative by-product coke ovens of the system known as the Koppers Oven and Direct Process Plant. They are arranged in four batteries of 70 ovens each, 2 batteries on the west and 2 on the east side of the main track system. (Plate XX A.)

Capital Stock: January 1, 1911; Common, $32,561,077.50. Preferred $248,300.00, (Authorized Common Stock, $50,000,000.00.)

Transfer Agents: Hanover National Bank, New York.

The Tennessee Coal, Iron and Railroad Company operates the following works:



BLAST FURNACES (NOS. 1 TO 6), TENNESSEE COAL, IRON AND RAILROAD COMPANY, AT ENSLEY, JEFFERSON COUNTY.

SEMET-SOLVAY BY-PRODUCT COKE OVEN PLANT. ENSLEY, JEFFERSON COUNTY.

Alice Furnace, Birmingham, Jefferson County Alabama. One stack, No. 2, (No. 1 dismantled in 1905). Stoves, six Gordon--Whitwell-Cowper. Furnace, 75x18, built in 1883 and put in blast July 24, 1883; rebuilt in 1902.

Product: Basic and foundry pig iron.

Annual Capacity: 84,000 tons.

Brand: "Alice."

Bessemer Furnace, Bessemer, Jefferson County, Ala. Nos. 1 and 2, each 75x16, built in 1886-87. No. 1 put in blast in 1888 and No. 2 in 1889; eight Whitwell stoves. Nos. 3 and 4, each 75x17, built in 1889-90, and No. 3 rebuilt in 1900; eight Whitwell stoves. No. 5 "Little Belle" 60x12, built in 1889-90; three Whitwell stoves. This furnace has not been in blast since 1906.

Ores: Red and brown ores from the Company's mines.

Product: Foundry and forge pig iron.

Brand: "De Bardeleben."

Capacity: 252,000 tons, annually on furnaces 1, 2, 3 and 4.

Oxmoor Furnaces: Oxmoor, Jefferson County, Alabama. Two stacks. No. 1, 75x17, completed in July 1877; rebuilt and blown in December, 1885; again rebuilt in 1902. No. 2, 75x17, first blown-in in March, 1876, rebuilt and blown-in in August, 1886; again rebuilt and blown-in in 1899; seven Whitwell stoves.

Ores: Red and brown ores from the Company's mines.

Product: Foundry and forge pig iron.

Brand: "Eureka."

Annual Capacity: On account of lack of steam and blowing power only one stack can be operated, leaving the remaining stack as an alternate. The annual capacity, one stack only, is 60,000 tons.

Ensley Blast Furnaces: Ensley, Jefferson County, Alabama. Six stacks, dimensions and capacity of which are as follows: Blast furnace No. 1, 22′ 10″x91′ 4″; capacity per annum, 144,-000 tons; No. 2, 22′ 6″x90′ 0″; capacity per annum, 144,000 tons; No. 3, 22′ 6″x92′ 3″; capacity 144,000 tons; No. 4, 21′ 9″ x84′ 6″; capacity, 120,000 tons; No. 5, 20′ 9″x86′ 7″; capacity

per annum, 108,000 tons; No. 6, 20′ 9″x86′ 7″; capacity per annum, 108,000 tons. Total capacity per annum, Ensley, 768,000 tons.

No. 1, built in 1898, blown-in March, 1889; rebuilt in 1901; dismantled and rebuilt in 1910-11, as a "Thin-lined" furnace, with water cooled shell, boiler plate, 1¼ inches at mantle and 1 inch at top, sprayed from top to mantle. No. 2, blown-in December, 1888; rebuilt in 1909-10. No. 3, blown-in June, 1888; rebuilt in 1908-09. No. 4, blown-in April 1888; rebuilt in 1907; No. 5, blown-in August, 1906. No. 6, blown-in April, 1905. (Plate XVII.)

Stoves: Nos. 1, 2, 3, 4 and 5 each have four 3-pass McClure stoves, and furnace No. 6, four 2-pass, central combustion Kennedy stoves.

Hoists: Nos. 1, 2 and 3 have electrically operated skip hoists; Nos. 4, 5 and 6 are equipped with steam hoists.

Product: Foundry, forge and basic pig iron.

Ores: Red and brown ores from the Company's mines.

Casting Machines: Two Uehling casting machines are in operation at Ensley.

Total Capacity: The total annual capacity of the furnaces of the Tennessee Coal, Iron & Railroad Company, in Alabama, is 1,164,000 tons.

WILLIAMSON IRON COMPANY.

General Offices: Birmingham, Alabama.

Officers at Birmingham, Alabama:

Furnaces: At Birmingham, Jefferson County, Alabama. One stack 65x14¾, built in 1886 and first blown in October, 1886; three (3) Massicks & Crooke stoves.

Fuel: Coke.

Ores: Red fossil and brown hematite.

Product: Foundry pig iron.

Annual capacity: 30,000 tons.

Brand: "Williamson."

The company owns 150 acres brown hematite in Blount County, not yet being worked, and 240 acres red fossil ore in Jefferson County.

BY-PRODUCT COKE OVEN PLANT, (KOPPERS SYSTEM) WOODWARD, JEFFERSON COUNTY. WOODWARD IRON WORKS.

WOODWARD IRON COMPANY.

General Offices: Woodward, Alabama.

Officers: J. H. Woodward, President; A. H. Woodward, Vice-President; R. H. Banister, Secretary and Treasurer; M. W. Bush, General Superintendent.

Stacks at Woodward:

No. 1 furnace in course of construction will be 90x22, with five two-pass stoves 110x22.

No. 2, 85x20, with four Foote stoves 90x20, and one Whitwell stove 80x20. This furnace was rebuilt in 1907.

No. 3, 85x20, with five Whitwell stoves 80x20. Built in 1905.

Annual Output: 340,000 tons.

The ore used is red fossiliferous hematite and brown ore, while the coke used is by-product coke made from Pratt coal. The by-product ovens (Plate XIX) have an annual capacity of 730,000 tons.

BIRMINGHAM COAL & IRON COMPANY

This company was acquired by the Woodward Iron Company on the first of April, 1912.

The officers of this company are the same as the officers of the Woodward Iron Company.

The Birmingham Coal & Iron Company was originally a consolidation of the Birmingham Coal Co. and the Birmingham Iron Co., the former company having owned about three thousand (3,000) acres of coal land in Jefferson County, Alabama.

Furnaces at Boyles, Jefferson County, Alabama. One stack 76.5x15.5; commenced building Feb. 9th., 1889; first blown in August 23, 1890; remodeled in 1897; rebuilt in 1899 and 1901; three (3) Massicks & Crooke stoves; annual capacity 60,000 tons. One stack 80x18; construction commenced August 1, 1906; first blown in May 8, 1908; four two-pass stoves, each 85x20.

Fuel: Bee-hive and by-product Pratt coke.
Ores: Brown and red hematite.
Product: Foundry iron.
Annual Capacity: 85,000 tons.
Brand: "Woodward."

This concern has bee-hive coke ovens of annual capacity of 135,000 net tons. After March, 1913, all coke will be supplied from the by-product ovens at Woodward, Alabama. The Company owns 12,000 acres of coal lands in Jefferson County, Alabama, 2,900 acres of red ore lands in Jefferson County, and 9,000 acres of brown ore lands in Cherokee, Calhoun and Cleburne Counties, Alabama, and Polk and Floyd Counties, Georgia. The Company also owns limestone deposits, but is not working them.

NOTE ON BY-PRODUCT COKE OVENS.

By-product coke ovens of the Semet-Solvay type have been in operation in Alabama for many years at Ensley (240 ovens) and at Holt, (40 ovens). In the second edition of this report there is an account of this type of oven by Mr. Wm. H. Blauvelt of that company.

In recent years another type (Koppers) has been introduced in Alabama, and some description of the main features of this type of oven will doubtless be welcome to the readers of this report. In this connection we give also a description of the plant of the Woodward Iron Company, by Mr. J. L. Haehnlen, Superintendent of the coke ovens of that company.

From a circular of the Koppers Company we give the following extract:

KOPPERS REGENERATIVE COKE OVEN.

Figures 1 and 2 show longitudinal and cross sections through the oven chambers, regenerator and heating flues. Fig. 1 is a longitudinal section through one of the walls, and shows the arrangement of the heating flues; Fig. 2 is a longitudinal section through the oven chamber and regenerator. The oven chamber is 39 feet long, 10 feet high and from 17 to 22 inches wide. These dimensions, however, vary slightly, according to the character of the coal to be used, the top of the oven is provided with three openings for charging the coal, and a fourth opening, through which the gases of distillation are drawn off to the condensing plant.

The clean gas is returned from the by-product plant by the main (D) placed in a position convenient for access, running along the whole length of the ovens on both sides. Branch supply pipes (H) conduct the gas into the gas-distributing channels (E) which are situated directly beneath the oven walls. These channels (E) are are formed of fire brick pipes. Thence it passes through the gas nozzles (F) into each vertical flue, where it ignites with the hot air

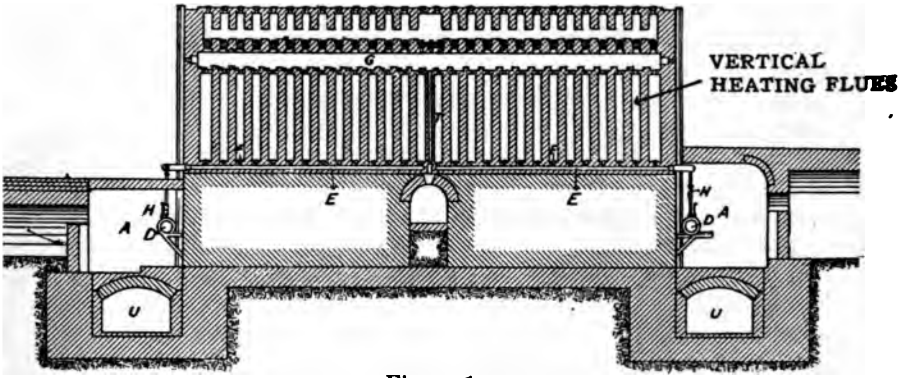


Figure 1.
Showing Arrangement of Heating Flues.

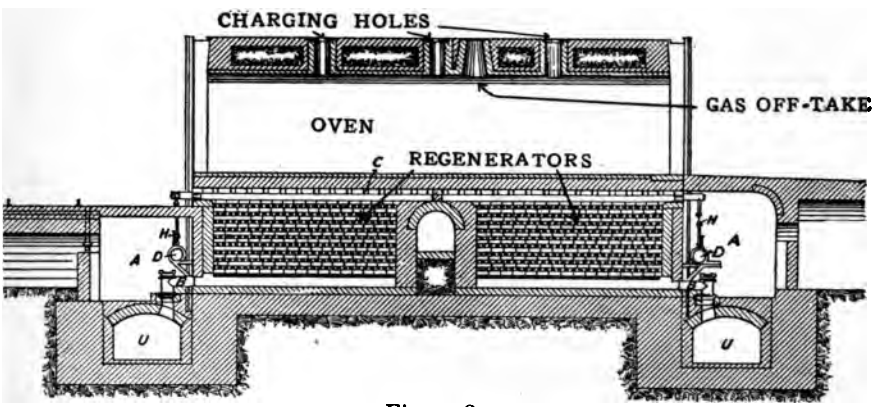


Figure 2.
Showing Longitudinal Section of Oven Chamber and Regenerator.

entering through the passages (C). The air for this combustion flows along the passage ways (A) at the front and back of the ovens, and thence it passes into the regenerators through the inlets (B). In the regenerators, the temperature of the air is raised to 2,000 to 2,200 Fa. (1,100 to 1,200C.) The highly heated air passes out of the regenerators into the vertical heating flues through the openings (C). A jet of flame is thus formed on a level with the oven floor in each of the vertical heating flues. The products of combustion pass up the heating flues, and through the openings (L) at the top of each flue. These openings are furnished with dampers which can be easily regulated to allow the exact amount of air to enter the flues necessary to effect perfect combustion. The sliding bricks are accessible from the top of the ovens through openings which are fitted with plugs easily removed.

A Brief Description of the By-Product Coke Oven Plant of the Woodward Iron Company. Woodward, Alabama.

By J. L. Haehnlen, Superintendent of Coke Ovens.

Since its organization, the Woodward Iron Company has produced the coke for its blast furnaces, in bee-hive ovens. In June, 1910, when it was finally decided that economic operation called for the adoption of the more modern method of manufacturing coke, this company had 756 bee-hive ovens, 182 of which were located at No. 1 Coal Mine at Dolomite, and 574 (150 of which were equipped with Covington Drawing Machine), were located near the furnaces. It may be mentioned, that the total distance from the coal mines to the blast furnaces is only about two miles.

Even with this number of bee-hive ovens operating fully, the Company was forced, occasionally, to purchase coke upon the open market.

In June, 1910, work was started on the erection of a by-product coke oven plant, using the Koppers Oven and the Koppers Direct Process of Ammonia Recovery. This plant was put in operation in April, 1911. It is located at a point midway between the company's coal mines at Dolomite and the blast furnaces, about one mile from each.

The original plant consists of one battery of 60 ovens (Shown in Plate XIX), together with the necessary coal handling machinery and apparatus for the recovery of by-products. Eeach oven of this battery has a capacity of 540 cubic feet, takes a charge of 13½ tons of coal and cokes in 18½ hours. The battery therefore carbonizes daily about 1,000 tons of coal, producing about 750 tons of furnace coke.

The plant has already demonstrated its success, and the Company in order to meet the demands of its new furnace at Woodword, and the furnaces at Vanderbilt, which were acquired with the purchase of the property of the Birmingham Coal and Iron Company, have now under way the construction of additions to the plant, which will bring its capacity up to 2,000 tons furnace coke per day. A second battery of 80 ovens is being built, of the same cubical content, but with certain

modifications in construction, which are confidently expected to reduce the coking time. Consequently the daily carbonizing capacity will be about 2,700 tons of coal.

Preparation of Coal: At present the dry unwashed coal as it comes from the mines, is elevated from the unloading hoppers by means of a cross conveyor and rubber belt to a Bradford breaker, from which it feeds to a hammer mill, which pulverizes it to a fineness so that 85% will pass a ⅛-inch screen. Another belt elevates it to the mixing bins, from which, by means of mixing belts, it is fed into the charging bin immediately over the ovens, and from which it is in turn fed to the electrically propelled charging larry. The Company, by this means, is enabled to so mix the coal from its various mines as to produce the quality of coke best suited to its needs.

Coal Washer: A coal washing plant of adequate capacity to supply the requirements of the enlarged coking plant has been decided upon and will be erected near by, forming a part of the same operation and will be ready to operate by the time the new ovens are completed. It will have a crushing capacity of 800 tons per hour, a washing capacity of 450 tons per hour, a storage capacity for 4,000 tons of unwashed coal and 6,000 tons of washed coal. Several novel features of construction and operation will be incorporated, which are expected to afford very efficient and economical operation. By means of cross conveyors, the dried washed coal will be delivered to one of the before mentioned conveyors and by it elevated to the mixing bins over the ovens.

Coke Screening Plant: The coke will be pushed from the ovens by means of a mechanical pusher into an open car of special construction which admits of rapid and effective quenching. Electric locomotives will take these charges to a central quenching station, then to the screening station which is now being built, where, by means of sizing rolls and revolving screens, the coke will be freed of all fine material and sent to the blast furnaces as a clean product of practically uniform size.

Emergency Loading Station: To preclude possibility of interruption in operation, due to break down and repairs on this screening station, an emergency coke loading trestle is located at one end of the batteries, from which the coke is dropped directly into the railroad cars.

By-Product Recovery Plant: The gas, as it is evolved from the coking charge, will be drawn, by means of exhausters, through overhead mains to six gas coolers of multitubular type, in which its temperature will be reduced to a point just below the dew point of the aqueous vapor which it contains. This will, of course, also condense out nearly all the tar, which, together with the weak ammonia liquor, drains to a tank, from which it is pumped into a separation tank, where, by means of the difference in specific gravity of the two, the liquor is decanted to one storage tank while the tar is drained to another in which it is further dehydrated, then pumped to a 1,000,000 gallon storage and loading tank, from which it is loaded into railroad tank cars for shipment.

Exhausters: The exhausters, which will draw the gas from the ovens and through the coolers, will be of the Turbo-Compressor type, which have proven so efficient for this work and are now being adopted in this country. Each compressor will have a capacity of handling 13,000 cubic feet of gas per minute and will make 3,500 R. P. M. The Turbine, of Curtis type, will be supplied with steam at 140 pounds pressure and will run condensing. There will be four of these centrifugal exhausters, two of which will draw gas from the ovens, one will be used as a booster to send surplus gas to boilers at central power plant, while the fourth will be convertible for either duty. On the pressure side of exhausters will be two tar extractors, the function of which is to remove from the gas, the fine tar fog which escapes precipitation in the coolers, and which may not be thrown out by the high centrifugal velocity imparted to the gas by the rapid revolution of the turbo-exhausters.

Reheaters: The gas is next led through the reheaters, three in number, two in service, one spare, where its temperature is raised to such degree that the aqueous vapor, which is still held in the gas, will not be condensed in the sulphate saturator.

Sulphate Saturators: There are lead lined cast iron vessels containing a sulphuric acid bath constantly maintained at a strength of about 6% excess H_2SO_4, through which bath, by a specially constructed distributing pipe, the gas is forced for the removal of its entrained ammonia. Two stills will be provided for distilling the ammonia gas from the aqueous con-

densate which is produced in the gas coolers, and this ammonia gas will be introduced into the gas stream, immediately ahead of the saturator and there be absorbed, together with the ammonia already entrained therein. There will be three saturators, two in use, one spare.

Three settiing boxes and four centrifugal drying machines will handle the sulphate, which by means of ejectors operated by compressed air, will be removed from the saturators as it is precipitated. This operation will, of course, be continuous. The sulphuric acid of 60 degrees, Beaume, will be fed in a constant stream to the saturators from any one of three elevated storage tanks, each of 75 tons capacity.

The dry sulphate is delivered to a storage room by means of small cars which are elevated to an overhead distributing track platform.

The washed gas will next be led through a napthalene washer to the gas holder, from which, part of it will be led to the ovens and boilers as fuel gas, and part will be drawn off by the booster and sent to the central power plant boilers and to any other points where it may be needed. The surplus gas amounts to 50% of the total gas evolved, and may be figured at 5,000 cu. ft. per ton of coal carbonized.

Analyses and Yields: Pratt Coal will be used, and based upon our present figures, the washed coal mixture and resulting coke will have the following analyses:

	Coal.	Coke
Moisture	6.00	2.00
Volatile Combust. matter	27.05	1.00
Fixed carbon	66.90	90.95
Ash	6.05	8.05
Sulphur	.85	.65
Phosphorus	.050	.060

From 2,700 tons of coal carbonized daily, the plant yields will be as follows:

Blast furnace coke	2025 tons.
Dust and small coke	80 tons.
Ammonium sulphate	27 tons.
Coal tar	16,000 gals.
Surplus gas	13,500,000 cu. ft.

The plant is also equipped with a small tar distilling plant, on which are made such quantities of refined tar, pitch, creosote oils and coal tar paint as are required for the Company's own use.

Water Supply: Water for the boilers, gas coolers and quenching will be supplied from the 10,000,000 gallon concrete distributing basin, which is now being built and to which it will be pumped from the 50,000,000 gallon impounding basin, by two Janesville motor driven centrifugal pumps. The distribution on the plant itself will be made from a 90 ft. stand pipe 8 ft. in diameter, which will be equipped with a float-controlled butterfly valve on inlet pipe coming from distributing basin.

Steam Supply: The steam for exhausters, ammonia stills and some of the pumps, will be supplied by four Rust boilers, aggregating 1,200 H. P.

Electric Power: Alternating current at 3,300 volts, 3 phase, 25 cycle is sent to the coke ovens from the central power plant, where, for all tractive power and some stationary motors, it is converted by Synchronous Motor Generators into direct current at 220 volts. Three of these generators, together with the necessary switch board, are housed in a splendidly equipped and well constructed sub-station.

In the coal handling plant, high tension alternating current is used, the motors operating Bradford breaker, hammer mill and long conveyor belt, being induction motors. The small motors operating pan feeders and mixing belts are D. C. 220 volt. The two combination coke pusher and coal leveler machines, the two coal larries, the two electric locomotives, the air and gas reversing motors, and the oven door extracting machines are all supplied and operated with direct current at 220 volts, as is also the mud grinding pan and various centrifugal pumps used in the by-product department.

Exterior lighting is all done by flaming arc limps; Mazda lamps, with special fixtures, are used for much of the interior lighting.

Based upon the results already obtained from the present battery of 60 ovens, the prediction may safely be made that the completed plant of 140 ovens will lend itself to a remarkably economical operation.

CHAPTER X.

LIST OF CHARCOAL FURNACES.

BASS FOUNDRY AND MACHINE COMPANY.

General Offices: Ft. Wayne, Indiana.

Officers at Ft. Wayne, Indiana: J. H. Bass, President; C. T. Strawbridge, Vice-President and Secretary; G. M. Leslie, Treasurer; Robt. J. Fisher, Assistant Treasurer.

Officers at Rock Run, Alabama: J. M. Garvin, Manager.

Furnaces: At Rock Run, Cherokee County, Alabama. One stack 53 feet 6 inches by 11 feet 2 inches, built in 1873-4; enlarged in 1881 and 1892, and rebuilt in 1894 and 1907; warm blast.

Fuel: Charcoal.

Ore: Local brown hematite.

Prduct: Pig iron for car wheels and strong castings.

Annual Capacity: 15,000 tons.

Brand: "Rock Run."

EAGLE IRON COMPANY.

General Offices: Chattanooga, Tennessee.

Officers at Chattanooga: Charles A. Lyerly, President and Treasurer; W. S. Shelow, Vice-President and General Manager; Frederick Giddings, Secretary.

One (1) stack at Attalla, Etowah County, Alabama, 55x11, built in 1888-89 and blown in June 15th, 1889; iron stoves.

Ores: Red and brown hematite from Etowah and Cherokee counties, Alabama.

Products Car-wheel pig iron.

Annual Capacity: 18,000 tons.

Brand: "Rome."

ROUND MOUNTAIN IRON AND WOOD ALCOHOL COMPANY.

Officers at Cincinnati, O.: Thos. H. Kelly, Receiver, No. 41 East Fourth Street.

Furnace: At Round Mountain, Cherokee County, Alabama. One stack, 45x9½, built in 1853; rebuilt in 1874, and remodeled in 1888; cold blast.

Fuel: Charcoal.

Ores: Red fossiliferous and brown hematite.

Product: Low phosphorus and high grade car-wheel pig iron.

Annual Capacity: 6,500 tons.

Brand: "Round Mountain."

Connected with the furnace are charcoal pits and kilns. By-products, Acetate of Lime and Wood Alcohol.

SHELBY IRON COMPANY.

General Offices: Shelby, Alabama.

Officers at New York: B. Y. Frost, Vice-President.

Officers at Hartford, Conn.: W. W. Jacobs, President.

Officers at Shelby: A. H. Avery, Assistant Treasurer; Jos. W. Keffer, Manager.

Furnaces: At Shelby, Shelby County, Alabama. Two (2) stacks, Nos. 1 and 2, each 60x14, built in 1863 and 1873; No. 1 rebuilt in 1889; warm blast.

Ore: Brown hematite obtained on the furnace property.

Product: Car-wheel pig iron.

Total Capacity: 40,000 tons.

Brands: "Shelby."

The Company makes annually about 2,000,000 bushels of charcoal.

CHAPTER XI.

STEEL MAKING IN ALABAMA.

FRANK H. CROCKARD.

The first steel made in Alabama was poured March 8th, 1888, at the plant of the Henderson Steel Manufacturing Company, North Birmingham. The original furnace was of 13 tons capacity and made 200 heats before it was closed down, during which time about 1600 tons of steel were made. The pig iron used was mottled and white of local production.

The Henderson Company was succeeded by the Jefferson Steel Company which operated the North Birmingham furnace in 1892 and 1893, making perhaps 1,600 tons of steel. The operations were suspended during the summer of 1893, all practical development ceasing until July 1897.

The total tonnage of basic Open Hearth steel made at North Birmingham from native local pig iron up to July 1897 did not exceed 3,500 tons, if indeed it reached 3,000 tons. At this period the Birmingham Rolling Mill Company started their first Open Hearth furnace July 22nd, 1897, followed by the second, on October 25th, both designed and built by S. K. Smythe & Company of Pittsburg, Pa. These furnaces were of 35 tons capacity each and used basic iron made at the Alice Furnace within 200 yards of the mill.*

The quality of the material produced at this plant was excellent. The last heat was poured at this plant November 12th, 1907. The plant at this period was operated by the Tennessee Coal, Iron and Railroad Company, under lease arrangement with the Republic Iron and Steel Company. The ingots were shipped to the Blooming Mill at Ensley and there rolled into rails or billets, which latter were used at the Bessemer Rolling Mill. On account of commercial considerations the plant was abandoned upon the completion of the second steel plant at Ensley.

*The above data obtained from Iron Making in Alabama, Second Edition.

Encouraged by the success of the Birmingham Rolling Mill Company's furnaces, and desirous of securing a more profitable outlet for pig iron, which had gone as low as six dollars per ton, the Tennessee Coal, Iron and Railroad Company started work July 14th, 1898, on a ten-furnace plant, designed by Wellman, Seaver & Company, of Cleveland, Ohio. This plant was completed and cast its first heat on Thanksgiving day, November 30th, 1899.

These furnaces were of fifty tons capacity and produced about 22,000 tons monthly, when operated in conjunction with a Bessemer Converter.

This plant was abandoned in 1908, and replaced by four 100 ton furnaces. Since that time, two additional furnaces were completed during 1908, and two more in 1910, making a total of eight furnaces which when operating to full capacity, should produce from 70,000 to 75,000 tons per month.

During a period of approximately one and one-half years prior to June, 1904, five Open Hearth furnaces were built by the Alabama Steel and Wire Company at Gadsden, Alabama. This plant was taken over by the Southern Steel Company in December, 1905, and subsequently, in July, 1909, by the Southern Iron and Steel Company. The Southern Iron and Steel Company started rebuilding the five old Open Hearth furnaces in September, 1909, and at the same time commenced the erection of an additional 50 ton furnace, which was completed in April, 1910.

The iron and steel production in Alabama since 1897 is shown in the following table. The column showing the percentage of iron used in the manufacture of steel is of interest as showing the use of a constantly increasing tonnage of Alabama iron within the State. This figure is obtained by assuming a yield of 90 per cent in the Open Hearth furnaces, and the use of 20 per cent scrap in all charges. No allowance has been made for the scale or ore additions:

Production of Pig Iron and Steel in Alabama.

(In Gross Tons.)

Year	Pig Iron Produced	Steel Produced	Tonnage of Pig Iron Used in Steel Making in Alabama. Tons.	Percent.
1897	947,831	2,819	2,506	.026
1898	1,033,676	9,692	8,615	.026
1899	1,083,905	8,543	7,594	.070
1900	1,184,337	66,076	58,734	4.9
1901	1,225,212	113,524	100,910	8.2
1902	1,472,211	176,252	156,659	10.6
1903	1,561,398	152,958	135,993	8.7
1904	1,453,513	196,623	174,776	12.0
1905	1,604,662	305,117	271,213	16.9
1906	1,674,848	320,327	284,785	17.0
1907	1,686,674	319,620	284,107	16.8
1908	1,397,014	341,336	303,410	21.7
1909	1,736,617	349,462	310,633	17.6
1910	1,939,147	529,684	470,830	24.3
1911	1,712,211	456,576	405,845	23.7

Neglecting special methods, the following processes are used in producing the steel of the world: Acid Bessemer, Basic Bessemer, Acid Open Hearth, and Basic Open Hearth. (The Crucible process invented in 1740, by Huntsman of Sheffield, England, is not here considered, as the tonnage made by this method is small and the product used for the higher grade lines of manufacture, such as cutlery, special tool steel, etc.)

ACID BESSEMER.

The Acid Bessemer was invented independently by Sir Henry Bessemer of England and Wililam Kelly of America. Bessemer's patent was dated November 1856,* while Kelly's

*Bessemer's first patent was issued in January, 1855, and during the next two years he secured fourteen patents. The claims of William Kelly, Kellyville, Kentucky, to priority of discovery were allowed, however, and he was paid $50,000 and an annuity of $12,-500 by those who took over the Bessemer patents in the United States. The first Bessemer steel rails in the United States were rolled at the North Chicago Rolling Mill, May 24th, 1865, the blooms coming from the Wyandotte Steel Works, built in 1864. W. B. P.

was issued in January 1857. The product was generally known as Bessemer steel, and gradually displaced wrought iron for most industrial uses, a partial list of which embraces plate, rails, structurals, bars pipe, tubes and wire.

In the manufacture of Bessemer steel it is necessary to have an iron low in phosphorus, since this element is not eliminated during conversion. This requirement imposed the use of raw materials (coke, stone and ore) low in phosphorus, as Bessemer pig iron is ordinarily assumed to contain 0.10 per cent of phosphorus, or less. For a number of years this requirement was easily fulfilled by the use of the high grade Lake ores from the North in the case of the United States; Great Britain obtained a supply from her Cumberland District, Bilboa, Spain, or the very rich ores of Northern Sweden.

The process is a comparatively simple one. Molten iron direct from the blast furnace or cupola, is poured into a pear shaped vessel known as a converter, which is lined with an acid lining (ganister), blast under a pressure varying from 15 to 30 pounds is introduced through tuyeres placed in the bottom of the converter.

The oxygen of the air unites with the silicon of the bath which is an exothermic reaction, that is, a heat producing reaction. Later when the temperature becomes sufficiently elevated the manganese and carbon are oxidized, upon the completion of which the bath is poured into a ladle where an addition of ferro-manganese is made, in the case of soft-steel, or spiegeleisen in the case of rail steels. The metal is then poured into ingot moulds from which it is rolled into the finished shape desired.

As the ores of the Birmingham District produce an iron carrying about eight times more than the Bessemer phosphorus limit, it is manifestly impossible to use the Bessemer process with Alabama irons.

BASIC BESSEMER.

The Basic Bessemer Process was developed by three Englishmen, Suelus, Gilchrist and Thomas. In this method it is necessary to have a high phosphorus content in contra-distinction to the low phosphorus of the Bessemer. This element may be present in quantities varying from say 2 per cent to 3 per cent. The presence of 1.25 per cent

to 2.00 per cent of manganese is also desirable. The basic Bessemer iron is introduced into the converter as before, the lining of which is basic instead of acid, and is usually made of calcined dolomite. As the action of silica on such a lining is very severe, it is necessary to maintain a low silicon content in the irons, as much below 1 per cent as possible. Heat for the reaction is developed by the oxidation of the manganese and phosphorus. The carbon, manganese and silicon are eliminated as in the case of the Acid Bessemer. Upon the elimination of these elements the "after blow" follows, calcined lime having been previously added exists as a slag at this period affording an opportunity for the phosphorus to combine with the lime as phosphate of lime. This slag, frequently designated at "Thomas Slag," has an important value on account of the high phosphorus content, which may rangs from 16 per cent to 20 per cent of phosphoric acid. This slag is ground to about a 200 mesh fineness and finds a ready sale throughout Europe.*

This method has been largely used in the treatment of the irons produced from the extensive ore deposits of Alsace and Lorraine. It has not found application in Alabama for several reasons:

1st. The Red Mountain ores do not carry sufficient manganese to produce the manganese content required in the iron.†

2nd. The metallurgical losses are higher than those of other methods.

3rd. The irregular quality of the resulting steel.

While local ores would not produce a pig iron big enough in phosphorus, this could be readily accomplished by returning a portion of the highly phosphoric converter slag to the Blast Furnace.

ACID OPEN HEARTH.

The Acid Open Hearth Process is conducted in an acid (siliceous) lined, regenerative gas fired furnace. In this process the carbon, silicon and manganese are eliminated or re-

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*The price of phosphate slag, with 42 per cent of total phosphates, is quoted at $11.28 to $11.52 per ton.

†There are red hematite ores in the Birmingham district that carry from 2.50 to 5 per cent. of phosphorus, but they have not been utilized for making high phosphorus pig iron. (W. B. P.)

duced within specified limits. Sulphur and phosphorus cannot be removed by this process, the material charged consisting of pig iron and scrap must contain a lower average percentage of these objectionable metalloids than that desired in the finished product, due to the elimination or reduction of the carbon, silicon and manganese, and also on account of a slight absorption of sulphur from the producer gas.

The percentage of scrap charged may vary from 25 per cent to 75 per cent, depending upon the supply, price and character of the material.

The process is one of oxidization, under normal American conditions the manganese and silicon are oxidized during melting, leaving principally the carbon for oxidization after the charge has been melted. This is accomplished by maintaining the bath at a proper temperature and the addition of oxides in the shape of iron ores, when the oxidization has proceeded far enough the bath is tapped and a recarburizer added along with the necessary quantity of ferro-manganese. While the yield is high and the quality of the product is first-class, this method is not available for large operations in Alabama on account of the character of the pig iron.

BASIC OPEN HEARTH.

The Basic Open Hearth has a much wider application than the acid method, due to the fact that phosphorus and sulphur may be reduced or eliminated by this process.

This is effected in a furnace resembling that used in the acid process, save the lining, which is made of basic material. Magnesite either in the shape of bricks or calcined lumps is the best commercial material yet discovered for this purpose. Bottom patching is made with either calcined magnesite or calcined dolomite, or both.

Practically all of the magnesite used in this country for open hearth work is imported from Austria.

Pig irons containing much higher proportions of phosphorus are available for basic open hearth use than is the case with the acid method. For example, the irons made from Alabama ores will ordinarily range from .75 per cent to 1.00 per cent in phosphorus, or approximately ten times more than that contained in iron used in the acid open hearth. The remarks regarding the scrap additions in the acid process are also applicable here.

Aside from the character of the lining, the important point of difference between the acid and basic open hearth process is the addition of lime, either in the raw or calcined state, forming a strongly basic slag, which under the oxidizing effects of the flame and ore causes the phosphorus to combine with oxygen as phosphoric acid (P_2O_5). In the presence of lime and other favorable conditions this acid unites with lime, forming calcium phosphate.

The sulphur is partially eliminated by volatilization, by liquation of sulphide of manganese and by combination with the lime of the slag.

Upon tapping the bath into the casting ladle recarburization is effected by the addition of coke or anthracite coal, which is added in paper bags previously charged with a known weight of coal or coke.

In Northern practice the recarburizer is not infrequently an additional charge of molten iron. This requires an iron low in phosphorus, which is not available in Southern practice. Manganese is added in the usual manner, that is as ferro-manganese. Manifestly this process, or some of the modifications or combinations of which it is susceptible, is best adapted for the successful treatment of Alabama irons.

THE DUPLEX PROCESS.

In the "Duplex" process the Bessemer converter is used as an auxilliary in connection with the basic open hearth furnace, the converter performing the usual function of eliminating, partially or completely, the silicon, manganese and carbon, phosphorus and sulphur being later removed in the open hearth.

This general scheme was the subject of Ossan's German patent, which, for many years had a technical interest only. Steel was produced by this method at Witkowitz. The first attempt in America was that of the Tennessee Coal, Iron and Railroad Company at its Ensley, Alabama, plant, in November, 1899.

The method followed at Ensley is, briefly as follows:

Pig Iron from a group of six modern blast furnaces is conveyed in 25-ton ladles to a six hundred ton metal mixer, a smaller mixer of two hundred and fifty tons capacity acting

as a spare, or serving for Sunday metal only. Accurately weighed charges of pig iron are poured from the mixer into a ladle which runs on an elevated track and from which the charge is poured in either of two 25-ton converters (the largest in America.)

The converter is then turned up and blown to meet the order of the Open Hearth Department. That is, the iron is either "full blown" in which all of the silicon, manganese and carbon are eliminated, or "high blown" in which the silicon and manganese have been eliminated but a portion of the carbon remains.

The total carbon carried in the iron is about 3.8 per cent. It is practicable to get within .25 per cent of the carbon specified. The following tabulation is illustrative of the Bessemer practice:

Mixer Metal.

C. 3.08%, Si. .91%, S. .041%, P. .81% Mn. .40%

Ladle	Si.	C.	Mn.
1st	.01	.07	.01
2nd	.02	.06	.02
3rd	.02	.06	.02
4th	.03	2.76	.05
5th	.03	3.10	.05

The blown metal is transferred to the open hearth furnaces in an acid lined ladle mounted on a truck, from which it is poured by means of an overhead electric crane.

These furnaces have a capacity of 100 tons each. They are 45 feet long from port to port, and measure 16 feet in width, and are known as the modified Campbell Tilting type.

Before the introduction of the blown metal, they are charged with cold stock, consisting of calcined lime, ore, scale and scrap, in the order named.

When producing rail steel it is the practice to charge three soft or "full blown" converter heats and two "high blown" heats, the latter containing about 3.00 per cent carbon. During the charging of the "full blown" heats the open hearth bath remains quiescent; a rather violent reaction or "kick" as it is termed by the furnacemen characterizes the addition

of the first high carbon heat. The evolution of gases is so rapid that it blows out around the doors and ports. The frothing of the slag and metal is sometimes so active as to cause a temporary suspension of pouring the charge. The addition of the second high carbon ladle is marked by a milder reaction.

After the bath has again become normal, tests are taken for carbon and phosphorus, and if satisfactory the contents of the furnace are quickly poured into a 100-ton ladle, the slag accompanying the bath and overflowing the ladle through a special spout which diverts the slag into special slag cars, thus avoiding the usual mess of slag on the casting side of the furnace.

The ladle is then carried to the pouring platform by an electric crane of 150 tons capacity, at which point the metal is poured into ingot molds in the usual manner.

Recarburizing is effected by ladle additions of ferro-manganese and coke. Usually the heats are ready for pouring within an hour after the blown metal additions.

If there was any doubt during the early development of the Alabama steel industry as to the practicability of producing a satisfactory grade of open hearth steel from Alabama iron, that doubt no longer exists. It has been commercially produced to meet the most rigid specifications, and has not only successful competed with the products of Northern plants, but also those of England and continental Europe.

The pressing problems of today are not those relating especially to plant design or metallurgical methods, but rather to ways and means of diversifying the finished product, with a view of developing better and broader markets for steel products, conformable with the bountiful raw material supplies of the State, and particularly those of the Birmingham District.

That the Alabama Steel Industry, with its allied sister, the Pig Iron Industry, is of vital economic interest is perhaps more fully appreciated when one realizes the fact that the combined market value of the pig iron and steel products of Alabama, the greater part of which is produced in Jefferson County, was for the year 1910 equal in market value to one-half of the entire cotton crop of the State.

The factors constituting the fundamental elements of a successful development of the industry may be enumerated as follows:

1. Satisfactory railroad service, under which is included reasonable freight rates, sufficient equipment of proper type, and expeditious handling of traffic.

2. Establishment and development of steamship lines, permitting the cheap delivery of steel products along the Mexican Gulf and Atlantic ports, in order to meet the steadily growing competition of Eastern Mills. The ever increasing demands of South America are almost entirely neglected under existing facilities, or rather lack of facilities. These markets are now largely supplied by English, German and Belgian Mills. For the same reason, we cannot hope to reap any advantages from a finished Panama Canal, until the important factor of steamship transportation has been provided.

3. A sufficient labor supply for mines and mills. A kind Providence has so generously endowed the State with a supply of raw material, and in such juxtaposition as to warrant its classification as unique. It is worse than useless for mere man to boast of these extensive deposits if, after providing sufficient capital his work vaingloriously ends. It requires the trained direction of the engineer and the muscle of the intelligent workman to extract treasure from the chest of Mother Earth; and a finer discernment on the part of the factory technologist, and a greater skill on the part of the mechanic to produce the comparatively refined products of their work:

Why not then, give proper attention to a labor supply sufficient in number and in qualifications to permit the industry to develop rapidly and without imposing the burdens wrought by an insufficient and inefficient labor supply? In this the manufacturer can assist by offering fair wages, by maintaining his plants in first class sanitary condition, with reference to heating, lighting, ventilation, etc.

In this connection a noticeable advance has been made by some of the larger corporations during recent years in all those matters relating to plant-conditions endangering life or limb, large sums have been expended for safety appliances, covering all branches of the service.

It is also, in many cases, within the power of the manufacturer to directly or indirectly provide more attractive houses and yards for the employees.

Since the home is the keystone of the arch of civilization and the unit composing the town or city, it seems idle to state that the subject is one which should invite the attention of the truly progressive corporation, especially in those instances in which the plant is not located within the confines of a city.

The panoramic view of the town of Corey, Plate XX. B, furnishes a striking example of the substantial progress made in recent years along the lines of providing attractive surroundings, well built homes and first-class sanitary features. This city was projected and built for the special purpose of providing an industrial army with the conveniences dictated by the requirements of the modern high class town planning.

CHAPTER XII.

ROLLING MILLS AND BASIC OPEN HEARTH STEEL WORKS.

AMERICAN STEEL AND WIRE COMPANY OF ALABAMA.

General Offices—Ensley, Ala.

Officers: W. P. Palmer, President, Cleveland, O.; A. S. Chisholm, Assistant to President, Cleveland, O.; J. S. Keefe, Vice President, Chicago, Ill.; F. Baackes, Vice President and General Sales Agent, Chicago, Ill.; C. L. Miller, Vice President and General Superintendent, Chicago, Ill.; A. F. Allen, Secretary, Chicago, Ill.; F. L. Watson, Treasurer, Chicago, Ill.; C. A. Vogt, Auditor, Cleveland, O.; F. H. Daniels, Chief Engineer, Worcester, Mass.; E. E. Stone, General Purchasing Agent, Cleveland, O.; Charles MacVeagh, General Solicitor, New York City.

This plant is still in course of construction, the machinery having not yet been installed. We can therefore give only the above list of the officials of the company and a general view of the plant (Plate XXI).

CONNORS-WEYMAN STEEL COMPANY.

Succeeding Alabama Tube Company, Alabama Tube & Iron Works.

Officers: G. W. Connors, President; W. M. Hoke, Secretary and Treasurer.

Offices: Brown-Marx Building, Birmingham, Alabama.

Works at Helena, Shelby County, Alabama, started in March, 1873; enlarged in 1899. The Alabama Tube Works was succeeded by the Alabama Tube & Iron Works. The Alabama Tube & Iron Works was purchased by Connors-Weyman Steel Company in June, 1908, and is at present operated by them.

AMERICAN STEEL AND WIRE COMPANY'S PLANT AT COREY, JEFFERSON COUNTY.

The equipment of the Helena Plant consists of, one 8-inch, 3 stand, one 18-inch, 3 high, 3 stand, bar and light rail mills; one 9-inch, improved hoop and cotton tie mill, 5 stands; four coal fired heating furnaces.

Products: Light steel rails, steel hoops, cotton ties, fence posts, etc.

Capacity: 15,000 tons of above products per annum.

Note: Above information supplied by Mr. Connors, May 23, 1911.

BIRMINGHAM STEEL AND IRON COMPANY.

Owner: W. T. Adams, Corinth, Mississippi.

Works at Birmingham, Jefferson County, Alabama. Have one 10-ton Open Hearth steel furnace (not now in operation), Two (2) Gas Producers and one (1) electric crane of 12 tons capacity.

Product: General machinary castings and ingots.

Estimated Annual Capacity: 2,000 tons.

Fuel: Producer gas.

The furnace was built in 1904 and operated for a part of the years 1905 and 1906. Entire plant is for sale or lease.

ECLIPSE ROLLING MILL AND MANUFACTURING COMPANY.

East Birmingham, Jefferson County, Alabama. At present leased by the Southern Iron and Commission Company, Birmingham, Alabama.

Officers: R. C. Foster, President and Trueasurer, Birmingham, Ala.; W. D. Winburn, Vice-President and Secretary, Birmingham, Ala.

Works at East Birmingham, Jefferson County, Alabama. Built in 1904 and first put in operation on May 1st, 1904. Two heating furnaces; 4 trains of rolls.

Product: Bar iron.

Annual Capacity: 5,000 tons.

JEFFERSON STEEL WORKS.

North Birmingham, Jefferson County, Alabama.

Built in 1889-90. One 15-gross ton basic open hearth steel furnace; first steel made April 24, 1890.

Products Steel ingots.
Annual Capacity: 8,100 tons.
Fuel: Producer gas.
Brand: "Jefferson." (This furnace takes the place of an experimental Henderson Open Hearth steel furnace built in 1887-8 and which first made steel on February 27th, 1888. Hawkins' steel was experimentally produced at these works in 1897).

This plant has not been in use for several years and is practically abandoned. The first basic open hearth steel made in Alabama was produced in the old Henderson furnace, at this place, February 27th, 1888.

In the Directory of the Iron and Steel Works in the United States (Amer. I. & S. Assoc. Phila., 1904) it is stated that this plant belonged to the Union Iron & Steel Company, New York, but under date of April 6, 1907, this Company writes that it does not own any plants in Alabama. Works dismantled.

REPUBLIC IRON AND STEEL COMPANY.

Youngstown, Ohio.

Alabama Works, Gate City, Jefferson County, Alabama, established in 1887-8; put in operation February 1888; since remodelled; 23 single puddling furnaces, 2 gas heating furnaces; 3 trains of rolls (18-inch muck and 8-inch guide, and 16-inch bar.)
Products Bars, bands, hoops, light T-rails, angles from 1 to 2½ inches, and light channels.
Annual Capacity: 24,000 tons.
Fuel: Coal in puddling furnaces and producer gas in heating furnaces. Being dismantled in 1911.

BIRMINGHAM ROLLING MILLS.

Birmingham, Jefferson County, Alabama.

Established in 1880; first put in operation in July, 1880; since enlarged and remodelled. Six double and 24 single puddling furnaces; 6 scrap furnaces, 7 gas, 4 box annealing, 2 pair, and 4 sheet and annealing furnaces, 10 trains of rolls (one 8-inch guide, one 12-inch guide and 16-inch bar, two

GENERAL VIEW OF STEEL AND WIRE WORKS, GADSDEN, ETOWAH COUNTY. SOUTHERN IRON AND STEEL COMPANY.

18-inch forge, two 24-inch sheet, one 26-inch plate and one 24-inch finishing, all hot, and one cold sheet train) and two spike machines. Two Siemens, 30-gross ton basic open hearth steel furnaces, built in 1897, first steel made July 22nd, 1897; annual capacity 35,000 tons of ingots.

Product of Mill: Iron and open hearth steel bars, plates, sheets, angles, round-edge tire, small T-rails, fish plates, railroad spikes, etc.

Annual Capacity: 70,000 tons of rolled material and 2,400 tons of spikes.

Fuel: Coal and producer gas.

Dismantled, 1910 and 1911.

SHEFFIELD ROLLING MILL COMPANY.

General Offices: Sheffield, Alabama.

Officers at Sheffield: J. W. Worthington, President; N. P. LeSueur, Vice-President; J. H. Pritchard, General Manager; J. W. Moore, Secretary and Treasurer.

Works at Sheffield, Colbert County, Alabama. Built in 1897-8 and first put in operation October 1898; 12 double puddling furnaces, three heating furnaces and four trains of rolls (one 3-high 18-inch Muck and Billet, one 3-high 16-inch bar (not erected) and 10-inch guide and one 10-inch hoop and cotton tie.)

Product: Bar, rod and band iron, also iron and steel hoops, cotton ties, cotton-tiebuckles and railroad and boat spikes.

Annual Capacity: 30,000 tons.

Fuel: Bituminous coal.

This Company was succeeded by the North Alabama Rolling Mill Company.

SOUTHERN IRON AND STEEL COMPANY.

(For officers, etc., see under Coke Furnaces, Chapter IX.)

Steel plant, wire mill, etc., Alabama City, occupying 240 acres of land.

(Plates XXII, XXIII and XXIV.)

The first wire manufactured in Alabama was at Ensley about 1900 by the Alabama Steel & Wire Co., from Steel

made by the Tennessee Coal, Iron and Railway Co. The results were, in a degree, satisfactory, although not as good as obtained in the north, using Bessemer Steel. It lacked the uniformity of composition necessary for the best results, due in a measure probably to the fact that the Steel Company were in the rail business and used the high carbon steel for their product, while the wire company needed a different quality for theirs. However, it would be right to say that they were successfully drawing wire out of the steel furnished them.

In 1902 they discontinued using the steel of the Tennessee Company and commenced making their own steel at Gadsden, Alabama, continuing to operate their wire department at Ensley. It has been stated by the wire company that the steel made by themselves at Gadsden was noticeably more satisfactory for their purpose; no doubt due to the more intimate knowledge they had of their particular business and being able also to control the manipulation from the ore to the billet.

In 1907 the Ensley plant was abandoned and a new rod and wire finishing plant was erected at Garsden in connection with the blast furnace and steel plant there making a most compact and homogenous plant, and one of the few of its kind in the United States, where the ore is received in its raw state and is carried on through its successive stages, finally into wire and its finished products. This plant has been operating practically continuously for the past two years, when it started, producing successfully the almost innumerable kinds and grades of wire and wire products required by the trade, and making the different grades of steel necessary for the successful manipulation and production of these various products, and on a manufacturing basis comparable with the best practice anywhere, making their steel by the straight OH process, using a mixture of 65 per cent pig iron and 28 per cent scrap.

The plant consists of a 300-ton blast furnace for making pig iron; Six 50-ton open hearth furnaces (capacity 60 tons) for converting the pig iron into steel; a blooming mill for rolling steel ingots into billets, of sufficient capacity to roll more than the output of the open hearth furnaces; the most modern and probably the largest capacity rod mill in the United States for rolling the billets into wire rods; a wire drawing mill of modern design for drawing the rods into plain wire; and the various finishing departments for consuming the

WIRE DRAWING ROOM, SOUTHERN IRON AND STEEL COMPANY, GADSDEN, ETOWAH COUNTY.

Barbed Wire Machinery, Gadsden, Etowah County. Southern Iron and Steel Company.

Open Hearth and Bessemer Department, Tennessee Coal, Iron and Railroad Company at Ensley, Jefferson County. 1. No. 2, Open Hearth Cold Finishing and Railroad Docks at Bottom. 2. Bessemer or Converting Department. 3. No. 1 Open Hearth. 4. Blooming and Rail Mill.

product of the wire drawing mill, including the manufacture of barb wire, nails, field fence, and various kinds of plain wire, annealed or galvanized.

This plant is in the process of rounding out by extending and adding to its wire drawing and finishing departments to bring them up to the capacity of the rod mill. which is approximately 500 tons in 24 hours.

The statement is made by the present management that there is no known scientific or metallurgical obstacle to development of this plant up to any desired tonnage and that it is operating as a practical and economical unit, and that they are successfully schooling and using a very considerable percentage of native labor both white and colored which furnishes a satisfactory supply when intelligently handled and properly housed. The Company also produces for the open market, high carbon forging billets and soft rolling billets and a full line of merchant bars, rounds, flats and squares, tire steel and mine rails.

TENNESSEE COAL, IRON AND RAILROAD COMPANY.

(For list of officers, etc., see under Coke Furnaces, page 199)

BESSEMER ROLLING MILLS.

Bessemer, Jefferson County, Alabama.

Built in 1887-8 and put in operation September, 1888.

Six heating furnaces, one annealing furnace, three trains of rolls, one 16-inch bar mill, one 8-inch guide mill, with 10-inch roughing, one 84-inch plate mill, seventeen Siemens gas producers. A concrete bar twisting department of 2,500 tons annual capacity has been added.

Product: Open hearth steel bar, guide and plates, light and heavy up to 84 inches, light rails and twisted concrete bars.

Capacity: 65,000 tons annually.

ENSLEY STEEL WORKS.

Ensley, Jefferson County, Alabama.

(Plates XXV, XXVI, XXVII, XXVIII, XXIX and XXX.)

Old Plant: The former open hearth plant, built in 1898-9, first heat poured November 30, 1899, consisted of eleven 50-

ton, Basic Open Hearth Furnaces, 10 tilting and one stationary, with an annual capacity of 350,000 tons of ingots; one reheating, coal-fired furnace, five 4-hole soaking pits; one 44-inch blooming mill and one 27-inch rail train, equipped for the production of either steel rails, splice-bars, small billets, sheet bars, I-beams, channels or angles, the annual capacity being from 150,000 to 300,000 tons. The first steel was rolled November 14th, 1902.

The plant was also equipped with one 250-ton, rolling, acid lined, primary furnace, and one 15-ton Bessemer converter for desiliconizing and decarburizing molten metal for the open hearth furnaces. The primary furnace was first put in operation February 14, 1904 and the Bessemer converter February 17, 1904.

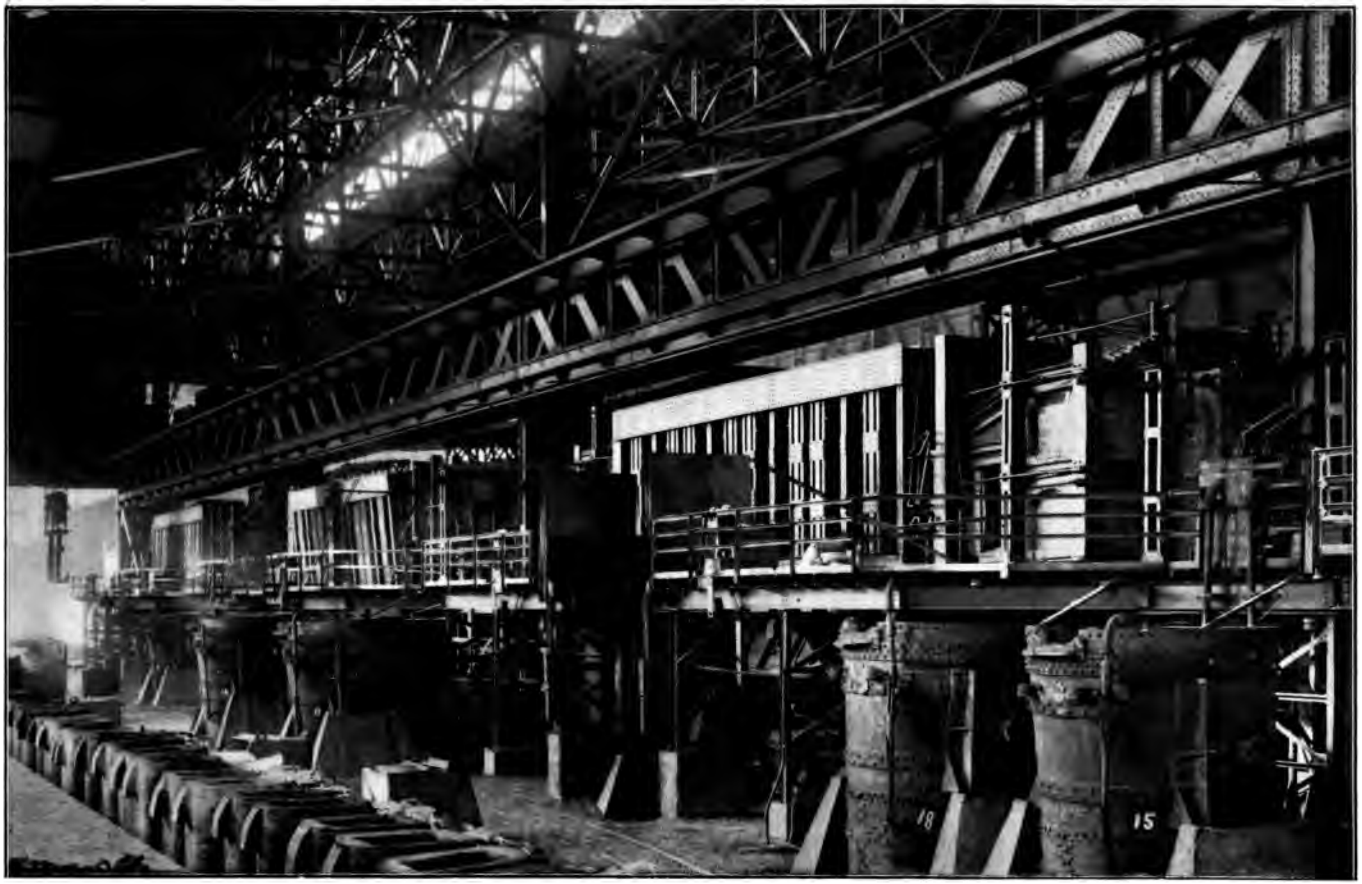
So many changes have been made since in the original installation that in order to keep abreast with modern conditions, there is very little left of the original plant at the present writing. The greatest alterations were made in the summer of 1908, when practically the entire rail mill was replaced by another designed by the company's engineering department and built by the United Engineering and Foundry Company, and at the same time complete new mill tables, including new manipulating apparatus, were installed in the blooming mill.

During the years 1909 and 1910 the finishing department of the rail mill underwent many changes, the bed capacity being practically doubled, and two magnetic magnet loading cranes provided to handle the rails from the beds to the cars for shipment, or to place them in any desired location in the course of operation.

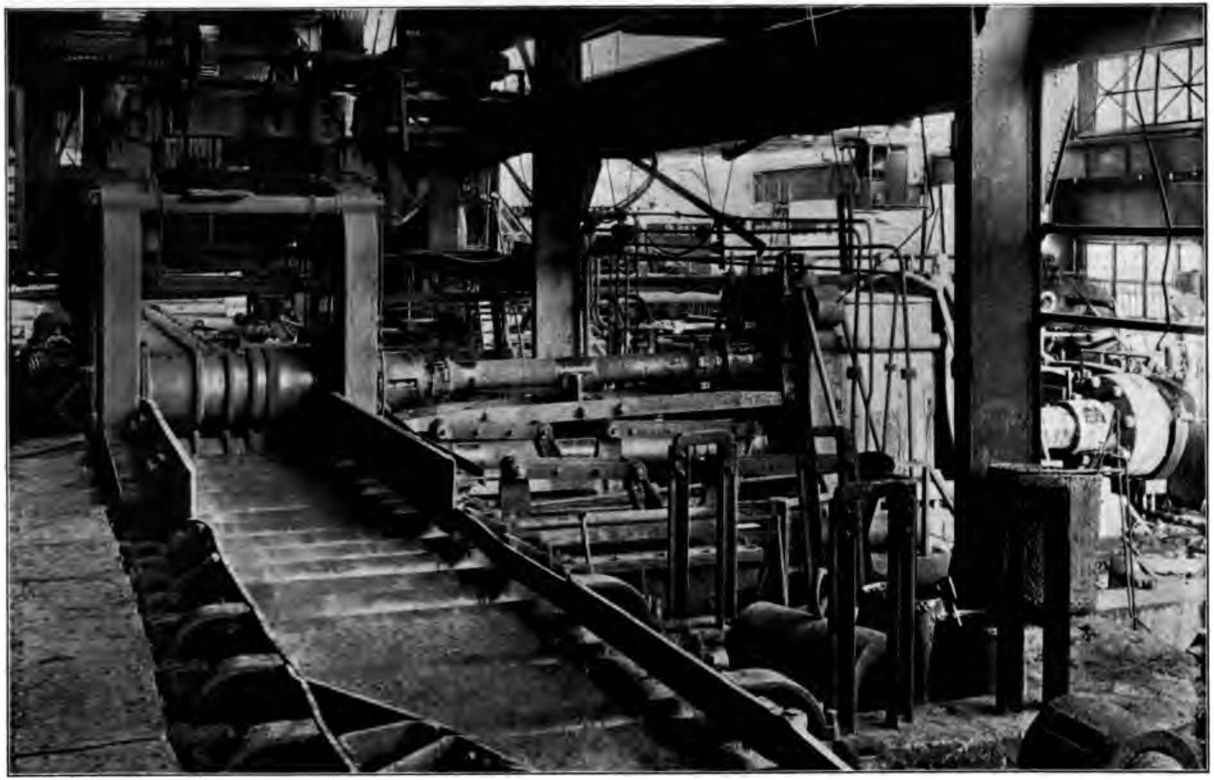
Present plant: The present equipment of the Ensley works consists of:

One 250-ton mixer, oil fired; one 600-ton mixer, oil fired; two 20-ton Bessemer converters, for desiliconizing; Eight 100-ton tilting, basic open hearth furnaces, served by 12 Hughes mechanical, self-cleaning gas producers, and 23 Laughlin, water bottom gas producers; one 44″ two high blooming mill, with 8 4-hole soaking pits and 1 preheating pit furnace for ingots; one 34″ two high roughing mill, and one 3-stand, 3-high rail mill, with one continuous re-heating furnace, coal fired; one 34″ two high, 4″x4″ billett mill, now under construction.

ENSLEY OPEN HEARTH PLANT, CHARGING SIDE OF FURNACE, ADDING BLOWN METAL. TENNESSEE COAL, IRON AND RAILROAD COMPANY.



ENSLEY OPEN HEARTH PLANT, CASTING SIDE OF FURNACE. TENNESSEE COAL, IRON AND RAILROAD COMPANY.



BLOOMING MILL, ENSLEY PLANT, TENNESSEE COAL, IRON AND RAILROAD COMPANY.

RAIL MILL, ROUGHING TRAIN, ENSLEY PLANT, TENNESSEE COAL, IRON AND RAILROAD COMPANY.

Capacity: Basic ingots 668,700 tons; blooms, large billets and slabs 566,700 tons, rails, 445,100 tons.

In connection with this plant there is also operated, at Ensley, Jefferson County, Alabama, a steel castings department, equipped with one 15-ton, stationary basic open hearth furnace, served by two water bottom gas producers.

Annual Capacity: 5,000 tons.

Also an iron foundry, equipped with two Whiting cupolas, annual capacity 5,000 tons. A new machine shop, 50x200 feet, with two 25-foot additions has been erected. The product of these shops is used in the plant.

A lime burning and dolomite refractory plant, supplying lime and calcined dolomite for open hearth requirements, has been constructed and is in operation.

WELLER ROLLING MILL AND FORGE COMPANY.

Gadsden, Etowah County, Alabama.

Officers: W. H. Weller, President; Jno. T. Weller, Vice-President; J. H. Harden, Secretary and Treasurer.

The works of this company at Anniston were destroyed by fire September 28th, 1905. They have been rebuilt at Gadsden. Two large heating furnaces; two trains of rolls (one 3-high 20-inch and one 3-high 12-inch) both used as finishing mills to operate on steel. There is no puddling department at present.

Product: The Company rolls merchant bar iron and steel, light T-rails and special shapes.

Capacity: About 15,000 tons annually.

Fuel: Coal and producer gas.

No owned and operated by Southern Iron and Steel Company.

WESTERN STEEL CAR AND FOUNDRY COMPANY.

Executive Offices: Old Colony Building, Chicago, Illinois.

Anniston Plant.

Officers: N. S. Reeder, Vice President Chicago, Illinois; F. P. Van Horn, Treasurer, Pittsburg, Pennsylvania; J. F. McNutty, General Manager, Chicago, Illinois; C. W. Wrenshall, Superintendent, Anniston Plant.

Twelve single and six double puddling furnaces; one heating furnace for scrap billets; three trains of rolls (one 18-inch muck, one 19-inch bar and one 10-inch guide) four hammers, viz., one 6,000-lb. steam, two 4,000-lb. steam and one Cuyahoga helve of 2,500 lbs. These hammers are used in the manufacture of iron and steel car axles, shafts, etc., the output amounting to about 9,000 tons annually.

The capacity for finished product of the trains of rolls is about 30,000 tons annually. The plant also includes gray iron and malleable foundries, a forge shop for railway and other forgings, a bolt and nut shop and a complete plant for the manufacture of wooden cars, the latter having a capacity of 25 cars a day.

Rail Loading Docks and Magnet Cranes, Ensley Plant. Tennessee Coal, Iron and Railroad Company.

CHAPTER XIII.

COAL WASHING IN ALABAMA.

By David Hancock, Consulting Engineer and Chemist, Birmingham, Ala.

"Coal-washing," so-called, is in the strict sense of the term not washing at all but a separation or classification of the coal and its impurities so far as the latter are mechanically mixed with the coal and can be separated from it by taking advantage of the difference of specific gravity between the coal and the shales, slate, bone coal, pyrites, etc., that form the impurities.

It will be evident that the extent to which such a separation may be effected will depend upon the nature of the impurities and how closely they may be intergrown with the coal.

It will be equally obvious that scarcely any two coals will present exactly the same conditions and that the problem of profitable coal washing becomes one of adapting the machinery available for the purpose, to each particular problem, in order to secure the best commercial results.

In Alabama the growth of the coal washing industry has been most intimately associated with the progress of iron making, in many cases making it possible to manufacture a high grade of coke from coal otherwise nearly worthless, and also, effecting a reduction in the cost of pig iron due to the removal at the mines of an immense tonnage of slate.

The final result is an improved structure in the coke, a smaller loss of breeze, less ash to flux in the furnace, requiring less limestone and less coke and last but not least, a very considerable increase in the uniformity of the coke product.

It can be demonstrated that a reduction by washing, of 5 per cent in the ash contents of a coal will effect a reduction of about $1.00 per ton in the cost of pig iron under the conditions generally prevailing in Alabama.

It is not strange then, that the coal washing industry in this State received its first impetus from the iron makers.

The success of many installations of washeries made in recent years, has naturally attracted the attention of those producing coal for fuel purposes only, and several washers have been erected by companies producing fuel coal.

There are probably few mines in the State where a coal washer would not produce good financial returns to the owners, if designed with a view to the particular problem in hand in each case.

Among the earlier successful washer installations in Alabama were the Luhrig at Sloss furnaces about 1890, a Stein at Brookwood and another Stein at Lewisburg about the years 1893-4. These washers, while containing principles of recognized merit were deficient in capacity and had complicated arrangements for sizing and handling coal and were later abandoned.

The first real impetus to coal washing was given by the Robinson washer (an importation from England) to which was added the Ramsay sludge tank for recovery of fine coal and water and separation of fine pyrites.

These washers, under the name of Robinson-Ramsay, were successful from the start. They possessed large capacity per unit, did not require sizing of the coal, and, on account of the fact that at the time (1894) most of the iron manufacturers were also sellers of the fuel coal, furnished a ready means of utilizing the slack coal for coke manufacture.

In the year 1897 there was washed in the State 1,337,545 tons of slack coal, practically all on Robinson-Ramsay washers.

About the year 1899 there was introduced into the State by Mr. Elwood A. Stewart, the inventor, a new type of washer in which a reciprocating jig with inclined bottom was used, with provision for continuous removal of slate and continuous circulation of water. The washer had large capacity (30 tons per hour per jig) and did not require preliminary sizing of coal. It met with instant recognition and adoption.

The first installation was made at Brookwood. The following figures show the result of a test made of the washer Jan. 9, 1901, by Mr. L. A. Gabany.

Raw coal used, 611 tons, 41 per cent Brookwood seam 49 per cent Milldale seam, 10 per cent Carter seam.

Analyses:

	Ash. Per Cent.
Brookwood	16.85
Milldale	11.60
Carter	10.30
Average	13.53
Sulphur 1.49%.	

Analysis of washed coal:

	Per Cent.
Ash	6.90
Sulphur	.79

Contents of the washed coal:

	Per Cent.
Pure coal	95.1
Bone coal	4.1
Slate	.8

Contents of the refuse:

	Per Cent.
Pure coal	4.0
Bone coal	9.6
Slate	83.6
Dust	2.8

The importance of the introduction of this washer to the coal industry of the State is impossible to estimate. Many iron manufacturers in the next few years, either wholly or partially discontinued the sale of fuel coal and crushed and washed for coke manufacture their entire run of mine product.

By the year 1910 the production of washed coal for coke manufacture had risen to 4,500,391 tons and since several

washers had been erected for the production of fuel coal, there is little doubt that more than 5,000,000 tons of washed coal was produced in the State in 1910.

The later improvements in washing have been directed toward more perfect elimination of impurities with smaller loss of good coal.

The old Luhrig type of jig, much modified and improved, and with capacity largely increased has no doubt returned to stay.

The two and three compartment jigs arranged so as to remove an intermediate product will no doubt produce the best result on small coal. When designed properly and supplied with coal of suitable size, they will deliver nearly pure coal on the one hand, nearly pure slate on the other, and intermediate product suitable for boiler fuel. There is little doubt but that washers of this type will be gradually introduced in those places where the very best possible results are required.

The Stewart type jig has been modified and put on the market in several forms with the idea of adapting it to certain needs.

Several Montgomery washers have been built in the State in the last few years. This washer uses a jig of the fixed or solid bottom type similar to the Luhrig except that it is inclined from back to front while the Luhrig is generally placed level.

Also, the plunger instead of being located in a separate compartment is placed immediately below the jig and is so equipped with flap valves that a pumping action is maintained through the screen plate. The speed and stroke of this plunger is commensurate with the speed and stroke of the Stewart.

In effect, it may be regarded as a combination of the Stewart and Luhrig principles. It is no doubt well adapted to certain conditions as the number of installations testifies.

Further improvements are to be looked for more in the direction of improvements in crusing and screening, improvements in detail of elevating and conveying machinery, and in a closer study of the problems involved in each particular case, rather than in the introduction of any new principles of washing.

In the case of the large majority of Alabama coals, the coal washing problem narrows down to a question of the efficiency of the separation of the ash forming impurities, since there are few mines where the sulphur is so high as to be objectionable for either coke manufacture or fuel purposes, or where there is serious trouble from fire-clay.

Therefore, the impurities to be separated are slate, shale, rash, bone coal or all together.

These impurities will be found in the various mines of the district in horizontal lenses or sheets of greater or less extent, and ranging in thickness from that of a sheet of paper to two feet or even more. When the thickness exceeds a couple of inches and the nature of the impurity is such that it does not shatter when the coal is shot down, it is generally more or less completely removed by the miner, the amount left in the mine depending upon the weight and color of the impurity as well as upon the carefulness of the individual miner.

Impurities thiner than two inches or those which shatter are rarely removed to any appreciable extent in the mine.

The usual method of procedure in an investigation of a prospective coal-washer proposition, is, first, to make what might be termed a "chemical survey" of the mine.

This consists in making a careful section of the coal vein in three or four places in the mine, taking samples of coal and impurities in the proportion which they exist in the vein.

The samples so obtained are broken down to a size commensurate with that to which the coal will be crushed in actual operation. A size commonly adopted is ¾ inch. The three or four samples are then mixed in equal proportion by weight, all fine material which will pass through a 20-mesh screen, sifted out for separate treatment and the main sample separated or classified by means of heavy solutions of varying specific gravity.

The objects obtained by such a procedure are, first, to obtain the theoretical ash or fixed ash of the pure coal, and second, to so classify the impurities as to plainly show the quantity, specific gravity, and ash contents of each class.

Thus, a certain mine in the State which presents a rather difficult washing problem showed the following results:

Composition of run of mine coal:

Pure coal less than 1.35 sg.	66.8%	Ash contents-- 7.68%
Impurities 1.35—1.40 sg.--	6.9%	Ash contents--14.60%
Impurities 1.40—1.45 sg.--	5.3%	Ash contents--18.54%
Impurities 1.45—1.50 sg.--	2.1%	Ash contents--23.82%
Impurities 1.50—1.55 sg.--	3.5%	Ash contents--28.42%
Impurities 1.55—1.75 sg.--	5.5%	Ash contents--35.78%
Impurities 1.75 & over sg--	9.0%	Ash contents--55.66%

Of course, the term "pure coal" is a flexible one, the division at 1.35 specific gravity between coal and impurities being entirely arbitrary and often requires considerable modification in special cases. However, the division at 1.35 has been sanctioned by custom, and since a logical comparison of results can only be made when the bases of the figures are similar, uniformity in selecting a line of division is desirable.

Having determined the nature and amount of the various impurities, the next question of importance to be settled is that of the size to which the coal should be crushed. This is determined to a large degree by the extent to which the impurities are intergrown with the coal. The purpose for which the coal is to be used often determines the size. If for fuel it is desirable to keep the coal as large as possible, if for coke the finer the better within reasonable limits.

If the coal crumbles readily and is finely crushed a large quantity of coal smaller than 20 mesh will be produced. In such cases the separation of impurities from very fine coal is imperfect and the washer loss is large.

On the other hand if the coal is too large, the action of the jigs is seriously interfered with by the large pieces of heavy slate and the separation is imperfect.

As a general proposition the Stewart type of jig is more satisfactory on coarse sizes and the Luhrig type on the small coal. By Stewart type is meant those jigs which reciprocate in a practically water tight tank and are provided with an inclined perforated bottom. By Luhrig type are meant those jigs which consist of a jig box with a fixed or rigid perforated bottom the water being pulsated by a plunger located in a connecting compartment either at the side or rear of the jig box.

There are several forms of jigs of each of these general types, and they differ from each other in construction details, such as style and location of the valves, plungers, etc.

These various forms have been designed to meet certain conditions and it will readily be seen that the coal washer as a whole should consist of a number of units for crushing, screening, and jigging coal, all carefully selected and combined after a close study of the peculiar conditions to be met in each case.

The best results can not and should not be expected unless the preliminary investigation has been accurate and thorough.

A "Chemical survey" of a mine, such as briefly outlined, will, if properly conducted give accurate information on the following points:

1. The amount and character of impurities in run of mine coal.
2. The amount of fixed ash, or ash in pure coal.
3. The amount of rejection which it will be necessary to make with a coal washer to produce any desired quality of washed product.
4. The amount and character of impurities, if any, which could be drawn off as an intermediate product and used for fuel coal, together with the heat value of such intermediate product.
5. The composition of washed product to be expected.
6. The size best adapted for the separation of impurities.
7. The units of machinery best adapted to produce the desired results with the least construction cost.

In other words such an investigation will show the financial returns which could be expected from a washer .

As to the actual performance of washers, it may be said in a general way that impurities lighter than 1.50 specific gravity are rarely separated by them to any considerable extent, and that a plant can be so designed as to eliminate practically all impurities heavier than 1.75 sg. and make a rejection of the larger portion of material between 1.50 and 1.75. There are few washers in operation, however, at the present time that are doing so well.

Also, if the coal is not too fine, there should not be more than 5 per cent of coal in the refuse and this amount will

usually be less than 1 per cent of the original weight of run of mine coal.

To show the efficiency of a washer, the writer has devised a chart upon which can be shown, graphically, the composition of the run of mine coal, washed coal, and refuse.

These are platted to scale and show at a glance the comparative efficiency of different washers as determined from actual tests.

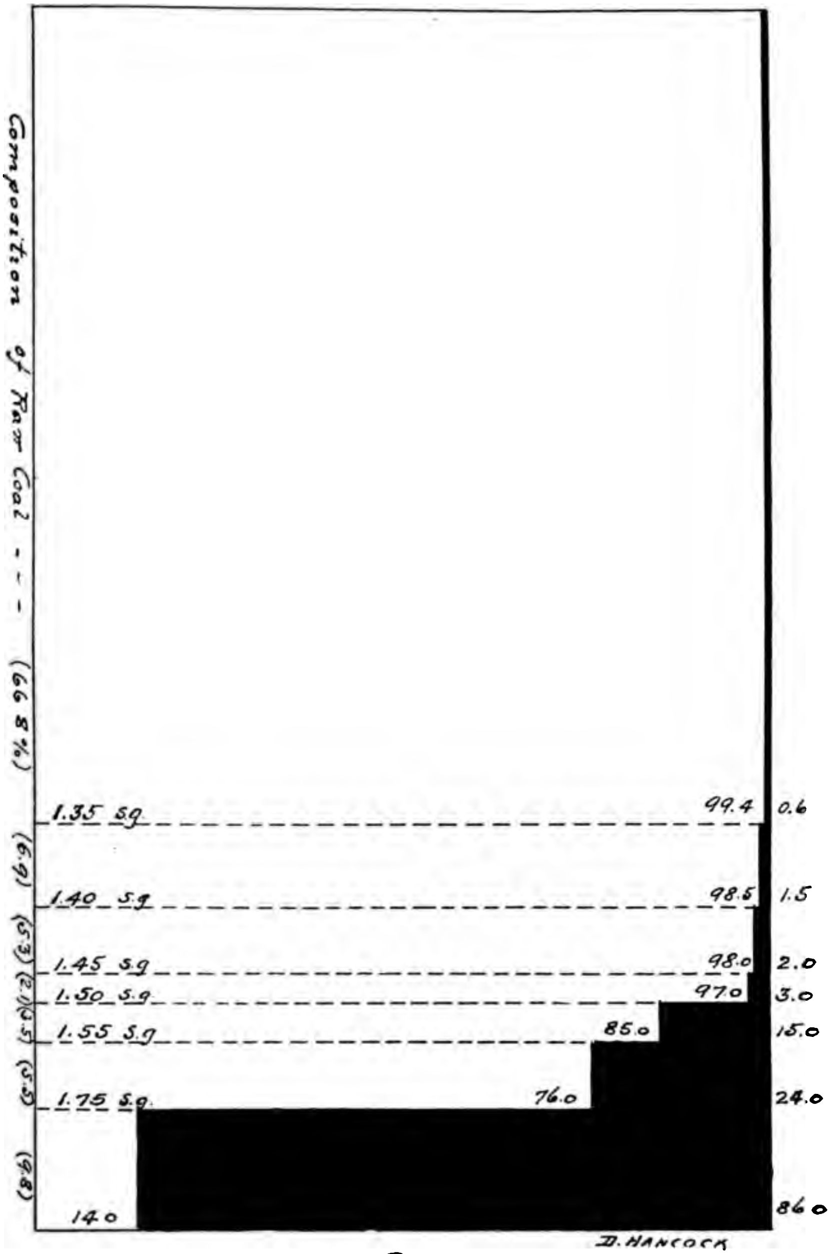
A specimen of such a chart is given herewith, representing the work on a washer of the Stewart type when working on the coal, composition of which was given on page 238.

It is necessary to know, first, the composition of the raw or unwashed coal. This is determined by separations made for each five points of specific gravity upon an average sample. On the left side of the diagram to any convenient scale is laid off the percentages found. For instance in this case the sample contained 66.8 per cent of coal lighter than 1.35 sg. therefore at the distance represented by this figure the dotted horizontal line is drawn and marked 1.35 sg. Also, the first class of impurity, separated between 1.35 and 1.40 sg. was found to be 6.9 per cent of the entire sample and this distance is laid off to the same scale and marked on the chart. After laying off the vertical scale in the same manner for the entire 100 per cent of raw coal the horizontal scale is then subdivided according to the per cent of each class of impurity found in washed coal as compared with the amount found in the unwashed. The balance, represented by the black area is the rejection or refuse, and both the quality and amount are indicated graphically, the areas being proportional to the weights of washed coal and refuse.

The figures to the right of the diagram show the amount of each class of impurity which goes to waste and the amount which is retained in washed coal. For instance it shows that 0.6 per cent of good coal is wasted, representing about 6 tons per day in this case.

It shows that practically no separation of coal and impurities is made below 1.50 sg. and that of the impurities heavier than 1.75 sg., 14 per cent is retained in the washed coal and 86 per cent rejected.

It should be noted in this connection that heavy impurities when retained in washed coal are usually fine material that



EFFICIENCY CHART.
Stewart type Washer on big seam Coal.

would pass through a ½ inch screen. With this type of washer the rejection of slate heavier than 1.75 sg. is practically complete in the coarse sizes, but imperfect on material smaller than ½ inch. In this case the coal was not sized preliminary to washing.

This chart can be appropriately called an "Efficiency chart" of a coal washer and is applicable to any type of washer and any coal if the figures upon which it is based are accurately ascertained in any given case.

In case of the washer shown by the diagram the ash of run of mine coal was 15.94 per cent and this was reduced by washing to 11.90 per cent, the coal being one of the most difficult to wash in the State.

In this case the amount of the rufuse was 10.8 per cent of the weight of run of mine coal.

As a rule the coals of the State will require the rejection of from 10 per cent to 15 per cent of the weight of run of mine to produce a good quality of washed coal.

The percentage of reduction of the ash from run of mine to washed coal has been and is still frequently cited as a guide in comparing different washer efficiencies. It is certainly a very unreliable guide unless the washers which are compared are working upon the same coal. It will be evident to anyone upon a little reflection that the percentage of ash reduction will depend more upon the nature and amount of the impurities in the coal than upon different types of washers.

I have before me figures showing an ash reduction from 21.50 per cent in run of mine coal to 4.50 per cent in washed coal, the work being done by a washer little, if any better than the washer which made a reduction of from 15.94 per cent to 11.90 per cent. The explanation is to be found in the difference in the amount and character of the impurities in the coal from the two mines and not in any essential difference in the washers.

Another result might be cited, outside of the State, however, where a washer amost identical with the one which produced the reduction of ash from 15.94 per cent to 11.90 per cent, showed the following results: ash of raw coal 21.40 per cent, ash of washed coal 3.08 per cent.

It is of course, absurd to suppose that any such difference could have existed between washers of identical construction,

and the difference is simply due to the fact that the two coals contain impurities quite different in character and amount.

One of the most difficult practical problems in coal washing occurs in cases of a very friable coal, when the crushing and screening operations produce a large amount of pulverized coal.

This fine coal works its way through the perforations in the bottom of the jigs, a portion also is held in suspension and carried around with the circulating water into the tank below the jigs. In this tank it settles out to a considerable extent and is known as the "hutch" material or "hutch werk."

In the majority of the washers in the State, no attempt is made to recover this fine coal, except that a certain automatic recovery takes place in the following manner.

The fine coal in the circulating water attaches itself to the stream of outgoing washed coal and refuse, roughly in proportion to the amounts of each, say in the proportion of 1 to 8 so that in this way probably 85 per cent of the fine coal goes into the washed product and 15 per cent into the slate refuse.

Practically no separation of coal and impurities is made on material finer than 20 mesh.

In some installations a sludge tank is introduced thus turning an additional amount of fine coal back into the washed product.

A more logical method would be to re-wash the hutch and sludge on a Luhrig type, fine coal jig and feldspar bottom, but there are at the present time no such installations in the State, and the practical difficulties of such a plan are many.

It is usually the part of wisdom to avoid pulverization of the coal as much as possible, but, in this respect also, each particular coal is a distinct problem.

A list of the coal washers in the State brought down to date is appended, and a statement of the production of washed coal in the State for coking purposes, annually from 1890 to 1911, may be seen in Table XV, page 150 of this Report.

COAL WASHERS IN ALABAMA—1912.

Location.		Type of Washer	Nominal Capacity	Operating Company.
Mine	County			
Acmar	St. Clair	New Century	2,500 tons	Ala. Fuel & Iron Co.
Acton	Shelby	Montgomery	800 tons	Ala. Fuel & I. Co.
Adger	Jefferson	American	1,200 tons	Tenn. Coal, I. & R. R. Co.
Altoona	Etowah	Montgomery	200 tons	Raccoon Mining Co.
Altoona	Etowah	Stewart	600 tons	Southern Steel Co.
America	Walker	Montgomery	300 tons	Stith Coal Co.
Banner	Jefferson	Stewart	1,200 tons	Pratt Consol. C. & I. Co.
Banner	Jefferson	Montgomery	600 tons	Pratt Consol. C. & I. Co.
Belle Ellen	Bibb	Montgomery	600 tons	Bess. C. I. & L. Co.
Bessie	Jefferson	Stewart	1,200 tons	Sloss-Shef. S. & I. Co.
Blossburg	Jefferson	Robinson-Ramsay	400 tons	Sloss-Shef. S. & I. Co.
Blossburg	Jefferson	Robinson-Ramsay	400 tons	Tenn. Coal, I. & R. R. Co.
Blossburg, west	Jefferson	Robinson-Ramsay	400 tons	Sloss-Shef. S. & I. Co.
Bradford	Jefferson	Montgomery	200 tons	Imperial C. & C. Co.
Brookside	Jefferson	Robinson-Ramsay	400 tons	Sloss-Shef. S. &. I. Co.
Brookwood	Tuscaloosa	Stewart	1,200 tons	Ala. Cons. C. & I. Co.
Coalmont	Shelby	Montgomery	600 tons	Helena-Cahaba Coal Co.
Colta	Jefferson	Jeffrey-Stewart	600 tons	Pratt Cons. C. & I. Co.
Corona	Walker	Montgomery	200 tons	Corona C. & I. Co.
Dora	Walker	Robinson-Ramsay	400 tons	Pratt Cons. C. & I. Co.
Empire	Walker	Stewart	600 tons	Empire C. & C. Co.
Flat Top	Jefferson	Stewart	200 tons	Sloss-Shef. S. & I. Co.
Garnsey	Bibb	Montgomery	600 tons	Galloway Coal Co.
Graves	Jefferson	Stewart	600 tons	Southern I. & S. Co.
Ivy	Walker	Pittsburg	1,200 tons	Sloss-Shef. S. & I. Co.
Kellerman	Tuscaloosa	New Century	1,000 tons	Central C. & I. Co.
Kellerman	Tuscaloosa	Stewart	1,200 tons	Central C. & I. Co.
Johns	Jefferson	Stewart	1,500 tons	Tenn. Coal I. & R. R. Co.

COAL WASHERS IN ALABAMA—1912.—*Continued.*

Location.		Type of Washer	Capacity Nominal	Operating Company.
Mine	County			
Lahusage	DeKalb	New Century	500 tons	Lookout Mtn. Fuel Co.
Margaret No. 1	St. Clair	Montgomery	800 tons	Ala. Fuel & I. Co.
Margaret No. 2	St. Clair	Montgomery	800 tons	Ala. Fuel & I. Co.
Marvel	Bibb	Shannon	600 tons	Roden Coal Co.
Mary Lee	Jefferson	Stewart	1,200 tons	Ala. Consol. C. & I. Co.
Mary Lee	Jefferson	Montgomery	600 tons	Ala. Consol. C. & I. Co.
Maxine	Jefferson	Stewart	600 tons	Pratt Consol. C. & I. Co.
New Castle	Jefferson	Stewart	1,500 tons	Anniston Iron Corp.
Pratt City	Jefferson	Stewart	2,100 tons	Tenn. Coal, I. & R. R. Co.
Pratt No. 1	Jefferson	Robinson-Ramsay	400 tons	Tenn. Coal, I. & R. R. Co.
Pratt No. 2	Jefferson	Robinson-Ramsay	400 tons	Tenn. Coal, I. & R. R. Co.
Pratt No. 4	Jefferson	Stewart	1,200 tons	Tenn. Coal, I. & R. R. Co.
Pratt No. 5	Jefferson	Stewart	1,200 tons	Tenn. Coal, I. & R. R. Co.
Pratt No. 3	Jefferson	Stewart	1,200 tons	Tenn. Coal, I. & R. R. Co.
Pratt No. 7	Jefferson	Robinson-Ramsay	400 tons	Tenn. Coal, I. & R. R. Co.
Republic	Jefferson	Stewart	1,800 tons	Republic I. & S. Co.
Pocahontas	Walker	Montgomery	300 tons	J. R. Pill Min. Co.
Red Feather	Walker	Montgomery	400 tons	Red Feather Coal Co.
Savage Ck.	Shelby	Montgomery	800 tons	Galloway Coal Co.
Sayre	Jefferson	Stewart	1,200 tons	Sayre Min. & Mfg. Co.
Sayreton	Jefferson	Stewart	1,200 tons	Republic I. & S. Co.
Searles	Tuscaloosa	Stewart	1,200 tons	Ala. Cons. C. & I. Co.
Short Creek	Jefferson	American	1,200 tons	Woodward I. Co.
Sumpter	Jefferson	Stewart	1,200 tons	Tenn. Coal, I. & R. R. Co.
Townley	Walker	Montgomery	600 tons	B'ham Fuel Co.
Townley	Walker	Montgomery	200 tons	Black Diamond C. Min. Co.
Wegra	Jefferson	Montgomery	800 tons	Pratt Consol. C. & I. Co.
Yolande	Jefferson	American	900 tons	Yolande C. & C. Co.
Youngblood	Bibb	Montgomery	600 tons	Bess. Coal, I. & L. Co.

SUPPLEMENTARY NOTE.

The manuscript of this report went to the printers in August, 1912. Some changes since that date, in the organization of certain plants have been noted during the reading of the proof, but the most important event during this interval is the completion in October of a diamond drill boring in Shades Valley within a mile of the base of Shades Mountain, since this gives a definite answer to the speculations on pages 36-38 of this report concerning the occurrence of red ore under Shades Valley, and to the estimates and conclusions of Mr. E. F. Burchard. (Bulletin 400, U. S. Geol. Survey pp. 126-129.) This boring shows that there is no falling off in the thickness and quality of the ore with distance from the outcrop, and that the depth of the ore below the surface at a distance of more than 2½ miles from the outcrop on Red Mountain is not too great for shaft mining. The drilling was done by Messrs Shannon and McDonough on Shades Creek, in the S½ of the NE¼ of the NE¼ of S. 8, T. 19, R. 3 W., at a distance of 14,500 feet in direct line along the dip from No. 7 slope of the Tennessee Coal, Iron and Railroad Co., on Red Mountain, (NW corner of the NE¼ of the SE¼ of S. 36, T. 18, R. 4 W.)

The elevation of the surface at the drilling is 595 feet. The top of the ore was reached at a depth of 1,902 feet and a section of the seam in descending order is:

Ore (Self-fluxing)	9 ft. 6 in.
Shale	4 in.
Ore (Siliceous)	9 ft. 6 in.

An analysis of an average sample of the drill core of the upper bench, made by David Hancock, shows as follows:

	Per Cent.
Metallic iron	39.51
Silica	9.94
Alumina	3.34
Calcium carbonate	24.20
Maganesium carbonate	.78
Metallic manganese	.20
Phosphorus	.32

The importance of this demonstration of a vast increase in the amount of red ore available immediately or in the near future, cannot well be over estimated. E. A. S.

Nov. 1, 1912.

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